South Fork Flathead Watershed Westslope Cutthroat Trout Conservation Program

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South Fork Flathead Watershed Westslope Cutthroat Trout Conservation Program

Bonneville Power Administration
Hungry Horse Dam Mitigation

U.S. Department of Energy
Bonneville Power Administration
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South Fork Flathead Watershed Westslope Cutthroat Trout Conservation Program

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Table of contents

Table of contents (cont'd)

List of Tables

List of Figures

List of Figures (cont'd)

Introduction

In 1999, Montana Fish, Wildlife & Parks (MFWP) began a program aimed at conserving the genetically pure populations of westslope cutthroat trout in the South Fork Flathead River drainage. The objective of this program is to eliminate all of the exotic and hybrid trout that threaten the genetically pure westslope cutthroat populations in the South Fork Flathead. The exotic and hybrid trout populations occur in several headwater lakes and their outflow streams. In 2001 MFWP released a draft environmental assessment, pursuant to the Montana Environmental Policy Act (MEPA), that addressed the use of motorized equipment to deliver personnel and materials to some of these lakes in the Bob Marshall and Great Bear Wildernesses (Grisak 2001). After a 30-day public comment period, MFWP determined that the complexity of issues was too great and warranted a more detailed analysis. These issues included transportation options for personnel, equipment and materials, the use of motorized equipment in wilderness, fish removal methods, fish stocking, and the status and distribution of amphibian populations in the project area. Because the program also involves the U.S. Forest Service (USFS) and Bonneville Power Administration (BPA), the environmental analysis needs to comply with the National Environmental Policy Act (NEPA). In October 2001, pursuant to NEPA, MFWP, along with the USFS and BPA initiated an environmental assessment to address these issues. In June 2002, the three agencies determined that the scope of these issues warranted an Environmental Impact Statement.

This specialist report describes the logistical, technical and biological issues associated with this project and provides an analysis of options for fish removal, transportation and fish stocking. It further analyzes issues and concerns associated with amphibian populations and creating new domesticated stocks of westslope cutthroat trout. Finally, this document provides a description of each lake, the best method of fish removal that would achieve the goals of the project, logistics for carrying out the fish removal, and the immediate management direction for each lake following fish removal. The USFS is preparing a specialist report detailing land management issues that relate to National Forest, designated Hiking Areas, and Wilderness. Information from these two documents will be used by BPA to prepare an Environmental Impact Statement.

Project rationale

MFWP file records indicate that as early as 1957 fish managers had identified sources of rainbow trout and Yellowstone cutthroat trout in the Graves Creek drainage, and as early as 1965 they had identified unknown sources of rainbow trout in the Big Salmon drainage and were concerned with the potential impacts that hybridization could have on the westslope cutthroat trout populations in the South Fork Flathead River drainage (MFWP 1965; MFWP 1957). There is little historical information detailing the stocking of rainbow trout in these areas. However, based on the practices of the times, it is believed that fish stocking in these drainages was unauthorized, or unrecorded during public fish distribution programs from the 1920's through the 1940's. Westslope cutthroat trout conservation in Montana became more active around 1980, and in 1983 MFWP commissioned a status review of westslope cutthroat trout west of the continental divide in which the South Fork Flathead River drainage was described as the largest and most secure stronghold for the species in Montana (Liknes 1984). The status review described the primary threat to the South Fork Flathead populations as hybridization with exotic trouts. This threat was defined as especially predictable in drainages with a lake in the headwaters. Many of the lakes had been historically stocked with exotic trout that have since been escaping downstream. By 1988 (Liknes and Graham), the westslope cutthroat trout was believed to exist in only 2.5% of its historic range.

In the early days of trout identification biologists relied on morphological features to visually determine if a fish was westslope cutthroat trout, Yellowstone cutthroat trout, rainbow trout, or a mixture of each. By the late 1970's and early 1980's technology was advanced to the point in which cost effective electrophoresis tests, conducted on small amounts of fish tissue, could identify proteins unique to each species. These proteins likewise are manifested in hybrid fish and provide an accurate determination of the level of hybridization at the population level. With a sample of 25 fish, geneticists have a 95% chance of detecting as little as 1% of hybridization in a population (Wenburg 2001a; Wenburg 2001b). The power of hybrid detection increases with sample size. To a great extent, this technology has been used to make such determinations in trout populations throughout the South Fork Flathead drainage. MFWP file data indicate that from 1983 to present nearly 130 genetic tests have been conducted by the University of Montana's Wild Trout and Salmon Genetics Lab on lakes and streams in the South Fork Flathead drainage (Sage 1993; Huston 1988, 1990, 1991; Rumsey and Cavigli 2000). From these tests, 38 separate populations have been identified as pure westslope cutthroat trout (Leary 2002). There is undoubtedly many other genetically pure stream dwelling populations that have not been tested because little evidence suggests they would be hybridized.

In 1983 MFWP began development of a genetically variable hatchery brood stock of westslope cutthroat trout that could be used in conservation programs throughout the state (Fraley 2002). In 1984 a second group of wild fish were infused into the brood and by 1985 the first offspring were planted into the wild. Efforts to control the level of cutthroat trout hybridization in the South Fork Flathead drainage formally began in 1985 with a program called "swamp-out". The program involved stocking high densities of genetically pure westslope cutthroat in several lakes that harbored exotic trout in an effort to progressively hybridize the exotic genes out of the population (Huston 1998). Initial time estimates for this program to be completely successful were 20-40 years (Hull 1986). Follow-up evaluations of the success of the swamp-out program were conducted in 1994. Some of the successes of swamp-out in the South Fork Flathead are described by Huston (1998) and later in this document.

In 1995, USFS and MFWP jointly developed the Fish, Wildlife and Habitat Management Framework for the Bob Marshall Wilderness Complex, and in 1997 added the Fish and Wildlife Decisions Supplement (USFS & MFWP 1997), hereafter referred to as the "framework document". The framework document provides guidelines for fish and wildlife management and conservation programs in the complex. Among the specific issues identified in the document are: management of threatened, endangered and sensitive species, fish stocking, and chemical treatment to control exotic fish, and fish spawn taking.

In 1999, eight state and federal agencies developed and signed the Memorandum of Understanding and Conservation Agreement for Westslope Cutthroat Trout in Montana (MFWP 1999a), hereafter referred to as the “conservation agreement”, which provided a framework for cutthroat conservation strategies in Montana. Primary among the conservation objectives is that:

> *…all genetically pure populations are to be provided the protection necessary to ensure their long-term persistence…*

In 1999 MFWP stepped up it’s commitment to westslope cutthroat conservation in the South Fork Flathead by proposing a plan that would remove exotic trout from lakes that were genetically contaminating downstream populations and risked hybridizing with pure populations throughout the South Fork drainage. From 1999-2002, MFWP has been working on developing a strategy and plan for implementing this project.

The objective of this project is to protect the existing genetically pure populations of westslope cutthroat trout in the South Fork Flathead drainage. To accomplish this objective, it will be necessary to remove all of the exotic trout from lakes and their associated streams. There are two issues that complicate completely removing all fish from the outflow streams. First, the rugged terrain makes access to some outflow streams difficult, and second the fact that federally endangered bull trout reside in the lower portions of many of the outflow streams requires safeguarding them from any fish removal project. For these reasons, we will remove as many of the exotic trout as possible from each stream and rely on genetically pure fish stocked in the headwater lakes to re-populate the stream systems and move them toward a genetically pure state. This document will evaluate the possible methods of meeting this objective.

Project Area

The South Fork Flathead River drains 1,681 square miles of land and is apportioned into four land use areas; the Bob Marshall Wilderness which comprises 967 square miles, the Great Bear Wilderness which comprises 118 square miles, the Jewel Basin Hiking Area which comprises 20 square miles, and the Flathead National Forest which comprises 576 square miles. The aquatic resources of the South Fork drainage are extensive. There are approximately 1,898 miles of stream habitat and 356 lakes. Of these lakes, 50 are known to have fish (Table 1), 8 others are purported to have had fish introduced but their present status is unknown, and the remaining 298 lakes are believed to be fishless. The average size of these 298 fishless lakes is 1.3 acres and ranges from 0.1 to 15.3 acres. The South Fork drainage was isolated in 1952 by the installation of Hungry Horse Dam approximately 5 miles upstream of its mouth.

Table 1. Fish population status of natural lakes in the South Fork Flathead drainage.

Pure westslope cutthroat (based on stocking records or genetic test)	Hybrid-based on UofM genetics lab tests	Suspected hybrid	Stocked or rumored stocked, present status unknown
Beta	Bighawk -lower	Crater	Christopher
Bighawk upper	Black	Three Eagles lower	Crimson
Big Salmon	Blackfoot		Hart
Blue	Clayton		Olar upper
Cliff	George		Olar lower
Devine	Handkerchief		Palisade
Diamond	Koessler		Pendant
Doctor	Lena		Recluse
Doris -upper	Lick		
Doris -middle	Margaret		
Doris -lower	Necklace -upper		
Jenny	Necklace -middle upper		
Jewel- north	Necklace -middle lower		
Jewel -south	Necklace -lower		
Jewel -east	Pilgrim -lower		
Jewel -west	Pyramid		
Marshall -upper	Sunburst		
Marshall -lower	Three Eagles -upper		
North Biglow	Wildcat		
Seven Acres- upper	Woodward		
Seven Acres- lower			
Soldier			
Spotted Bear			
Squaw			
Tom Tom			
Trout			
Twin -upper			
Twin -lower			

There are 20 lakes and their outflow streams that have been identified through genetic analyses as having hybrid trout populations. One additional lake, Lower Three Eagles, is suspected to contain hybrid trout based on the fact that Upper Three Eagles Lake contains westslope cutthroat X Yellowstone cutthroat hybrids, and it drains into the lower lake. Ten of these 21 lakes are located on National Forest and in the Jewel Basin

Hiking Area (Table 2) (Figure 1), and the remaining eleven are located in the Bob Marshall Wilderness (Table 3) (Figure 2, Figure 3, Figure 4).

Table 2. National Forest and Hiking Area lakes that harbor exotic trout in the South Fork Flathead River drainage.

Lake	Land designation
Wildcat	Jewel Basin Hiking Area
Clayton	Jewel Basin Hiking Area
Blackfoot	Jewel Basin Hiking Area
Black	Jewel Basin Hiking Area
Handkerchief	National Forest
Upper 3 Eagles	Jewel Basin Hiking Area
Lower 3 Eagles	Jewel Basin Hiking Area
Pilgrim	Jewel Basin Hiking Area
Bighawk	Jewel Basin Hiking Area
Margaret	National Forest

Table 3. Bob Marshall Wilderness lakes that harbor exotic trout in the South Fork Flathead River drainage.

Lake	Land designation
Sunburst	Wilderness
Woodward	Wilderness
Necklace lakes (4)	Wilderness
Lena	Wilderness
Lick	Wilderness
Koessler	Wilderness
George	Wilderness
Pyramid	Wilderness

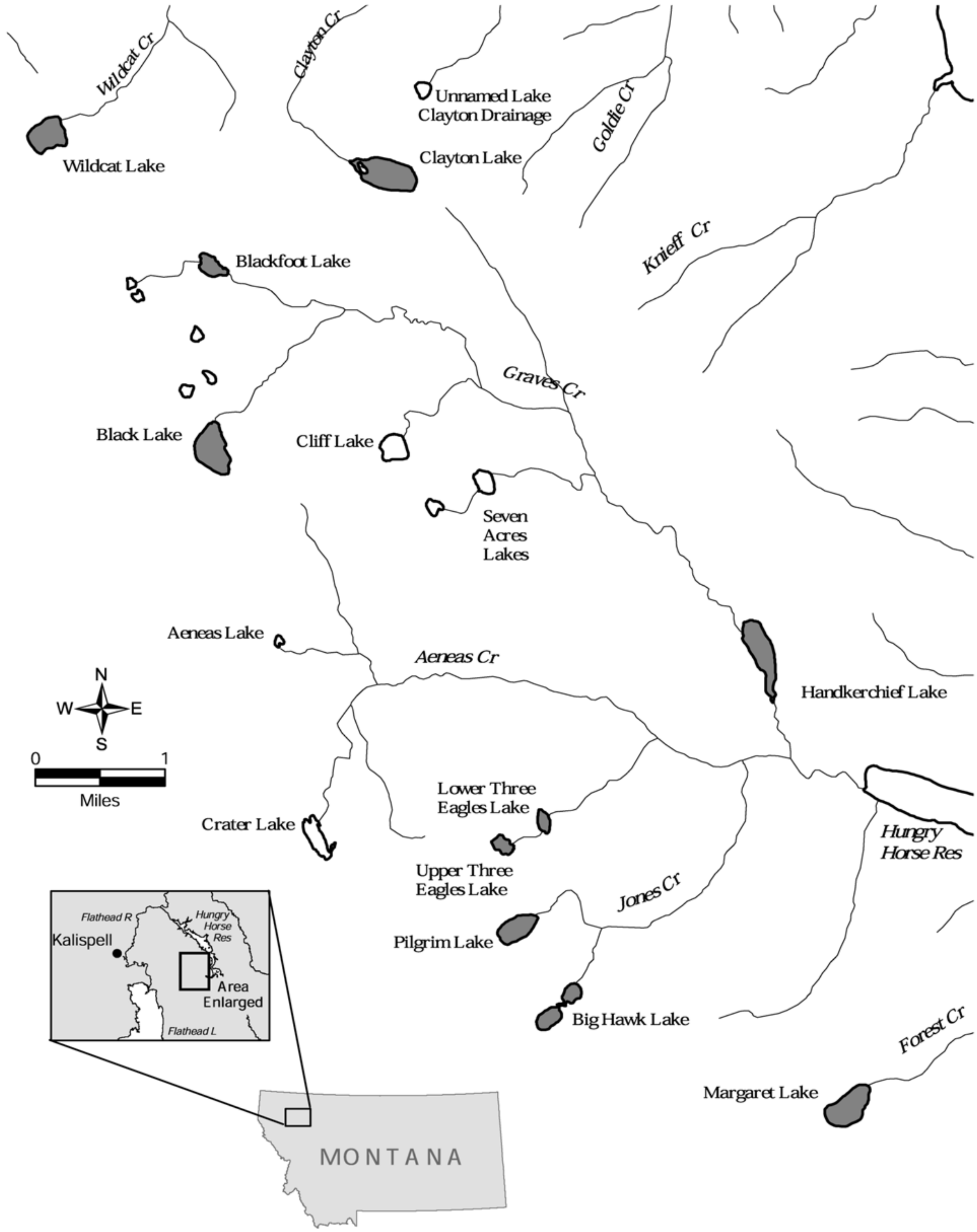

Figure 1. Map of non-wilderness lakes that contain hybrid trout populations, South Fork Flathead River drainage.

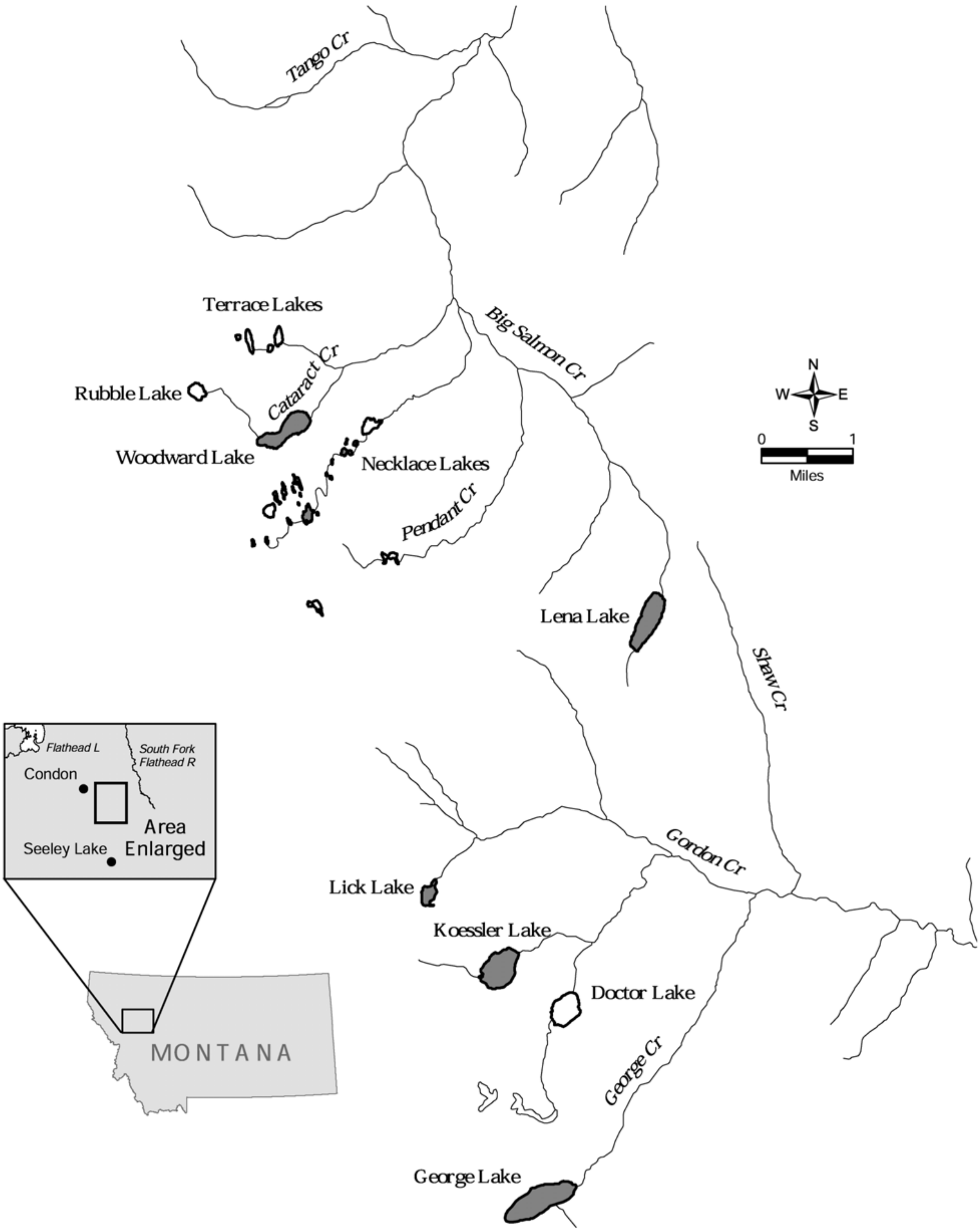

Figure 2. Map of wilderness lakes that contain hybrid trout populations, South Fork Flathead River.

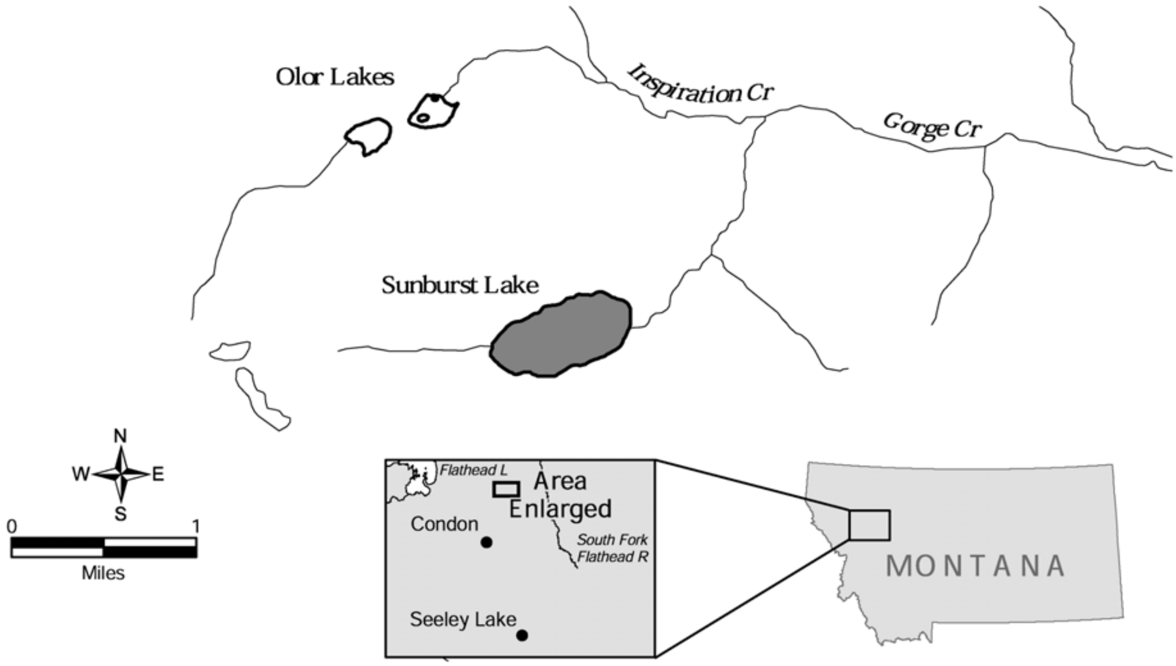

Figure 3. Map of Sunburst Lake, which contains a hybrid trout population, Bob Marshall Wilderness, South Fork Flathead River drainage.

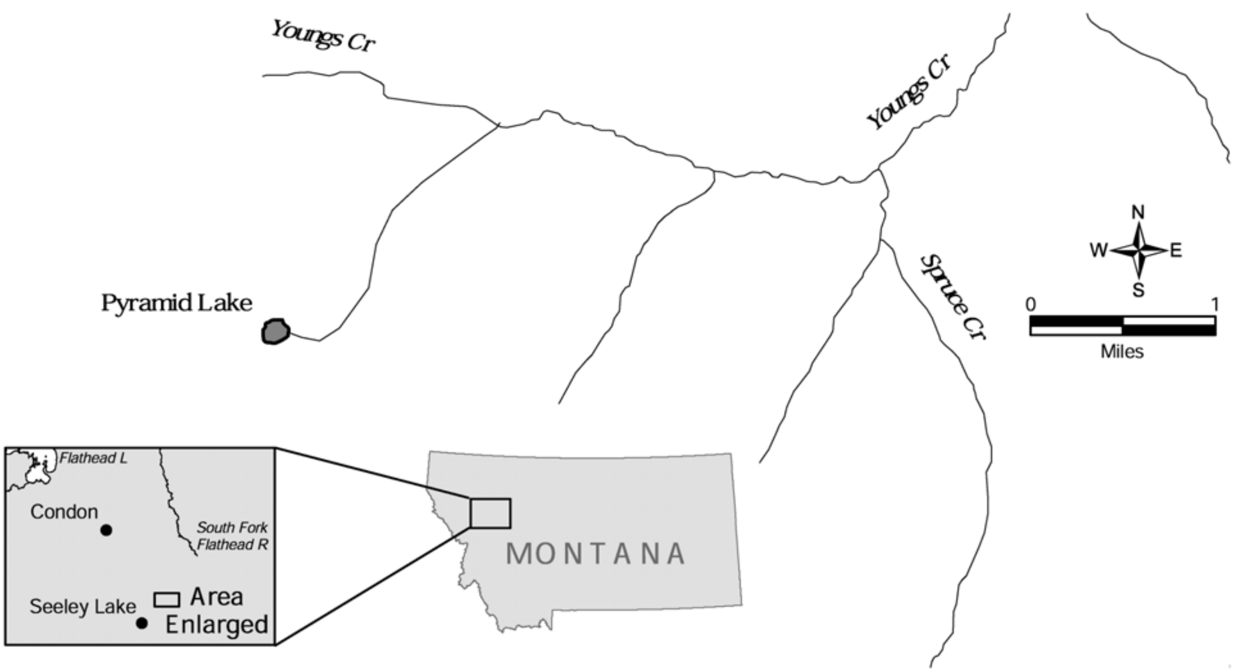

Figure 4. Map of Pyramid Lake, which contains a hybrid trout population, Bob Marshall Wilderness, South Fork Flathead River drainage.

Background and present legal status of westslope cutthroat trout

In June of 1997, the westslope cutthroat trout was petitioned for threatened species listing under the Endangered Species Act by American Wildlands, Clearwater Biodiversity Project, Inc., Montana Environmental Information Center, The Pacific Rivers Council, Trout Unlimited's Madison-Gallatin Chapter, and Mr. Bud Lilly (Federal Register 2000). The following information details the chronology of this activity:

June 6, 1997.–U.S. Fish and Wildlife Service (Service) receives a petition to list the westslope cutthroat trout as a threatened species throughout its range, pursuant to the Endangered Species Act (Act). Petitioners are American Wildlands, Clearwater Biodiversity Project, Idaho Watersheds Project, Inc., Montana Environmental Information Center, Trout Unlimited's Madison-Gallatin Chapter, and Mr. Bud Lilly.

June 6, 1997.–Period of 90-day petition review begins. Service must decide whether or not the petition presents substantial information indicating that the requested action (listing) may be warranted.

July 2, 1997.–Service sends a letter to petitioners stating that, on the basis of the Service's final listing priority guidance published in the December 5, 1996 *Federal Register*, the Service has determined that the petition falls into the Tier 3 category (i.e. low priority) and that westslope does not face "imminent, high-magnitude threats." The Service will proceed with the 90-day finding when completion of ongoing, higher-priority activities allows available funds to be allocated to westslope cutthroat trout.

September 4, 1997.–End of 90-day period for petition review.

September 24, 1997.–Petitioners send a letter (i.e. 60-day notice of intent) to Interior Secretary and Service stating that, unless the Service promptly issues the 90-day finding, the petitioners intend to pursue federal court litigation for alleged violations of the Act.

January 25, 1998.–Service receives from the petitioners an amended petition, which contains a substantial amount of new information on westslope cutthroat trout.

January 25, 1998.–Period of 90-day review for amended petition begins. Service must decide whether or not the amended petition presents substantial information that listing may be warranted.

March 17, 1998.–Petitioners file a complaint in the U.S. District Court for the District of Columbia requesting that the court declare that the Service's failure to issue a 90_day finding is a violation of the Act, its implementing regulations, and the Administrative Procedures Act, and that the court issue a preliminary and permanent injunction requiring the Service to issue a 90_day finding on the petition and promptly publish such finding in the *Federal Register*. The complaint was filed before the end of the 90-day review for the amended petition.

April 1, 1998.–Service sends a letter to the petitioners stating that, although the tier system for prioritizing listing actions remains in full force and effect, the Service is proceeding with preparation of a 90-day finding on the amended petition.

June 10, 1998.–The Service publishes a notice in the *Federal Register* (63 FR 31691) of a 90-day finding that the amended WCT petition provided substantial information indicating that the petitioned action may be warranted and immediately began a status review for WCT. In the notice, the Service requested data, information, technical critiques, comments, or questions relevant to the amended petition.

July, 1998.–The Service receives requests to extend the comment period from the Montana Department of Fish, Wildlife and Parks, the Idaho Department of Fish and Game, and U.S. Forest Service Regions 1 and 4. As a result, the Service announces reopening of the comment period in the August 17, 1998 *Federal Register* (63 FR 43901) and indicates that comments on the 90-day finding should be submitted to the Service by

October 13, 1998. A September 23, 1998 *Federal Register* (63 FR 50850) notice describes corrections to the preceding notice and the Service's need for 9 months from the date of the 90-day finding (June 10, 1998) to complete the status review.

September 30, 1998.–The U.S. District Court dismisses the petitioner's March 17, 1998 complaint pertaining to WCT.

March 26, 1999.–Legal representatives of the petitioners send a Notice of Intent to Interior Secretary Babbitt and the Service stating that, unless the Service promptly issued the 12-month finding, the petitioners intended to pursue federal court litigation for alleged violations of the Act.

August 5, 1999.–Legal representatives of the petitioners filed a complaint in the U.S. District Court for the District of Columbia requesting that the court declare that the Service's failure to issue a 12-month finding on the June 6, 1997 petition is a violation of the Act, its implementing regulations, and the Administrative Procedures Act, and that the court issue a preliminary and permanent injunction requiring the Service to issue a 12-month finding on the petition and promptly publish such finding in the *Federal Register*.

September, 1999.–The Service completes the status review for westslope cutthroat trout in the United States.

March 8, 2000.–The Service and its co-defendants reach an agreement with the plaintiffs that, among other things, on or before April 10, 2000, the Service shall submit for publication in the *Federal Register* a "warranted, not warranted, or warranted but precluded" determination regarding the westslope cutthroat trout in accordance with Section 4(b)(3)(B) of the Act.

April 6, 2000.–Service Director signs 12-month not-warranted finding for westslope cutthroat trout.

October 23, 2000- Plaintiffs file a lawsuit in federal court claiming the Service was arbitrary and capricious in it's not warranted decision.

November 2001- Oral arguments by plaintiffs and defendants are heard in federal court in Washington D.C.

March 31, 2002 -The court ruled that the Service must re-evaluate it's not warranted finding. In reconsidering whether to list the westslope cutthroat as a threatened species, the Service must evaluate the threat of hybridization as it bears on the statutory listing factors of the Endangered Species Act. The court gave the Service 12 months to make this evaluation.

Decisions to be made

Three agencies having decision-making authority in this project are signatories of the Conservation Agreement (MFWP 1999a); Montana Fish, Wildlife & Parks, Montana Department of Environmental Quality, and the United States Forest Service. The United States Fish and Wildlife Service is also a signatory of the agreement and will be providing recommendations for this project with regard to the Endangered Species Act.

MFWP has jurisdiction and responsibility to manage all fish and wildlife resources that occur on state, federal and private lands of Montana. The Region 1 Supervisor will be making a decision whether to remove hybrid trout from the proposed lakes and streams, decide which method is most appropriate for said removal, and decide whether to restock depopulated lakes with genetically pure westslope cutthroat trout.

Montana Department of Environmental Quality (MDEQ) has regulatory authority over the Montana Water Quality Act. The Water Protection Bureau will be making a decision whether to provide 308 authorization to allow a short-term exemption of Montana's surface water quality standards specifically for the purpose of applying an aquatic pesticide. Because the department issues each authorization for only 1 year, applications would be made by MWFP to MDEQ annually, and authorization would be granted on an annual basis.

The United States Forest Service (USFS) has jurisdiction and responsibility for the occupancy, use and management of National Forest lands including lands within the Bob Marshall Wilderness, Great Bear Wilderness, Flathead National Forest and Jewel Basin Hiking Area. For this project, the Region 1 Forester will decide whether to approve the use of fish toxicants within wilderness for the purpose of eliminating hybrid trout populations from lakes and streams, decide whether to approve short term use of outboard motors, pumps and mixers for fish toxicant application, and also decide whether to allow a helicopter to transport equipment, materials and personnel.

The Bonneville Power Administration (BPA) is responsible for protecting, mitigating, and enhancing fish and wildlife affected by the development, operation, and management of Federal hydroelectric facilities on the Columbia River and its tributaries. (See Pacific Northwest Electric Power Planning and Conservation Act (Act), 16 U.S.C. 839 et seq., Section 4(h)(10)(A)). BPA meets this responsibility, in part, by funding projects identified through a regional process led by the Northwest Power Planning Council. The South Fork Flathead Watershed/Westslope Cutthroat Trout Conservation Program, a portion of the Hungry Horse Dam Mitigation Program, was proposed by MFWP and BPA. The Forest Service is a cooperating agency. Following a thorough environmental review, both BPA and the Forest Service will each issue a Record of Decision (ROD). The ROD cannot be signed until 30 days after the Final EIS is issued. The project can proceed once the ROD is issued.

The U.S. Fish and Wildlife Service's mission is, working with others, to conserve, protect and enhance fish, wildlife, and plants and their habitats for the continuing benefit of the American people. It is the only agency of the U.S. Government with that primary mission. The Service helps protect a healthy environment for people, fish and wildlife, and helps Americans conserve and enjoy the outdoors and our living treasures. The Service's major responsibilities are for migratory birds, endangered species, certain marine mammals, and freshwater and anadromous fish. The Service will provide guidance under Section 7 of the Endangered Species Act. The Service will consult with BPA and make recommendations following a biological assessment of the potential impacts this project may have on already listed threatened or endangered species that occur in the project area.

An analysis will be conducted for each lake to determine which of the possible alternatives will best meet the goals of the project. The issues to be considered will include, method of fish removal, method of transport for materials, equipment and personnel, and whether to restock each lake following the removal of fish. Because some lakes occur in wilderness, some land use restrictions apply. Methodologies and activities will be further analyzed according to these land use restrictions.

Methods of Fish Removal

There are ten methods of fish removal or control that will be examined for consideration, they are; angling, barriers, explosives, genetic swamping, gill netting, seining, trap nets, electrofishing, introduction of tiger muskellunge, and fish toxin (antimycin & rotenone). Each method will be analyzed to determine which is best suited to achieve the objective of complete fish removal in each of the lakes and its stream network. In making this determination, consideration will be given to the management objectives of each lake and stream, and obvious limitations of each method.

Angling

MFWP has the authority under commission rule to modify angling regulations for the purpose of removing unwanted fish from a lake or stream. Unfortunately, this method does not guarantee complete removal of all fish. There are a number of reasons why this method may not work, especially in backcountry lakes. First, liberalizing bag limits does not guarantee every angler would keep all of the fish they catch primarily because of differences in value systems among anglers. Recreational angling has been shown to reduce the average size of fish and reduce population abundance. As the size of fish decreases, angler satisfaction tends to decrease also. For these reasons it may be difficult to attract anglers to a site for voluntary angling, if angling quality is poor. Second, caring for large bounties of fish in remote locations further dissuades anglers from keeping every fish they catch. Next, very small fish are not vulnerable to angling and require approximately two years to recruit into the fishery. During this time, adult fish have the opportunity to continue reproducing. Finally, anglers in remote rugged country do not typically target streams, especially those with little or no trail access. Lifting bag limits on streams would not likely succeed in removing fish due to difficulty in access. The amount of time required for anglers to depress or remove all fish from a lake would likely require many years to accomplish. For these reasons this method of fish removal was considered unreliable at achieving the objective of complete fish removal from the lakes and streams, and was not developed further. MFWP would pursue lifting bag limits two full seasons prior to any removal effort to reduce the number of fish in each lake and allow anglers to remove fish for consumption.

Downstream barriers

The use of a barrier device to contain exotic trout within the proposed lakes was considered. Barrier devices are commonly used to exclude fish from an area rather than contain them within an area. They are typically used in streams rather than lakes, and are used mostly to prevent upstream fish migrations. Rotary drum screens are commonly used on irrigation diversions to prevent fish from entering. Barriers have been used with some success to exclude fish from upstream migration in Muskrat Creek, Montana (Shepard et al. 2001). Thompson and Rahel (1998) reported that a gabion barrier in Wyoming was unsuccessful at stopping upstream migrants because it passed 18 of 86 marked brook trout. MDNR (1990) reported that barriers are not completely effective in most cases. It is near impossible to keep fish from moving downstream with the flow of water. Downstream movement barriers must account for excluding all sizes of fish to be effective. Smaller screen mesh is often used to exclude the smallest of fish, but it is prone to clogging from algae, leaves, pine needles and insect exoskeletons. It also increases the maintenance requirements necessary to keep the screen clean and functional. Several mechanical apparatus have been used successfully to harness the energy of the water to clean rotary screens. One such device is used on Hell Canyon Creek in the Jefferson River drainage of Montana (Ron Spoon, MFWP, personal communication, 2002). However, the structure is surrounded by a concrete box to keep leaves and sticks from fouling it.

Containing fish in a lake using a screen or barrier would require construction of a fortified structure at each lake outlet. These structures would have to contain fish at high flow and be able to function in low flow to prevent damming. Fish screens are designed for application on waterways where the flow can be controlled, most commonly on irrigation channels. If flow is too low, the screen would not pick up debris and deposit it downstream of the structure. If flow is too high, the screen may pick up fish and deposit them downstream of the structure. A rotary screen would not pick up coarse debris, which necessitates it being cleaned by an attendant periodically. The cost of installation can range from $2000/cfs to $7000/cfs (Mark Lere, MFWP, personal communication, 2002). This cost would most likely be increased greatly because the sites are located in remote areas. Because the structure is mechanical, it would require frequent maintenance to be effective. Fish screening mechanisms are prone to vandalism, especially in remote areas. Finally, rotary fish screens do not work in the wintertime because snow and ice cause them to freeze up. The greatest limitation in the use of fish screens in this project is that they do not remove exotic trout from a lake or stream. For these reasons, fish barriers and screens were not developed further for consideration.

Explosives

Pneumatic and percussion explosions were considered as a method to remove fish from a lake. The shock wave created by underwater explosions would kill fish by rupturing air bladders, rupturing inner-ear structures and most likely cause massive hemorrhaging in the gills and brain. Campbell and O'Neil (1999) found that pneumatic concussion during petroleum exploration under the ice caused severe internal damage to the swim bladders, gonads and kidneys of northern pike and walleye in Sturgeon Lake, Alberta, Canada. However, caged fish located 5 meters away from the sounding device suffered no injuries, and no delayed mortality was observed on any of the test fish after 72 hours.

A traditional explosive such as dynamite could be used to cause severe injury and death to fish. Lennon (1970) reported that explosives have been used to control fish populations, with only limited success against sharks and gars. Licensed professional blaster, Daniel Lewis, of Libby, Montana, was consulted to determine the feasibility of using explosives to remove fish from the project lakes. He recommended that 75% or 80% semi-gel dynamite should be used for such a project because of its water resistance, it won't detpress, and it throws a fast shock wave. In his opinion "an 85% to 95% kill can be expected on all living creatures in the water". Non-electric blasting caps would be needed to initiate the powder, primacord trunk line would initiate the non-electric caps, and a cap and fuse would be needed to initiate the primacord. Additionally, charges may have to be delayed to reduce damage to a lake bottom or surrounding structure. Millisecond (MS) connectors would be required along the primacord trunk line to create the necessary delays. A geologist would be needed to conduct a comprehensive geological survey of the area to determine whether rock fissures in the lakebed would be opened up (possibly dewatering the lake), or an avalanche would be triggered as a result of the shock wave. At least two professional blasters would be needed at each lake and would require approximately 2-4 days to survey and develop a blasting plan, 2-3 days set a grid of charges to cover the surface and depth. A final day would be required for the blasters to retrieve lines, make sure every charge was detonated, and to clean up the refuse from the explosives. A motorized raft would be required to safely and efficiently set up the explosives. The amount of dynamite necessary to accomplish this objective would be between 2 and 5 pounds per acre-foot. All of the necessary blasting materials could be safely packed by livestock, or airlifted by a helicopter. Packing explosives into Woodward Lake for example would require 4,500 pounds of dynamite, and an estimated 1,000 pounds of detonating materials (caps, fuses, primacord, connectors, rope, floats and weights). Assuming each mule can carry 175 pounds, approximately 31 mule loads would be required to transport materials only to Woodward Lake. Additional stock would be required for rafts, motors, camp, SCUBA, and personnel.

Based on the estimates of only 85% to 95% success of a complete fish kill, the apparent difficulty of using explosives in many miles of stream environment, and the lack of information available that indicates this method has been successful at removing all live fish from deep lakes in remote rugged mountainous terrain, this method was found to be in-effective at achieving the goal of complete fish removal from the lakes and streams, and was not developed for further consideration.

Genetic swamping

This method refers to stocking high densities of genetically pure fish in lakes with exotic trout to promote hybridization and ultimately breed the exotic genetic material out of the population. In 1985 MFWP began a pilot program to swamp exotic trout from several lakes in the South Fork Flathead. The initial time estimated for this method to be successful was between 20 and 40 years (Huston 1998; Hull 1986). After the first eight years of stocking genetically pure westslope cutthroat trout, four of five lakes in the project showed an increase in the percentage of westslope cutthroat genes (Huston 1998). One of those lakes, Blackfoot, showed an improvement from 25% westslope x 75% rainbow in 1986 to 65% westslope x 35% rainbow in 1994. However, from 1994 to 2001 the genetic composition has been virtually unchanged despite the lake being stocked six times between 1995 and 2001 with 16, 268 genetically pure westslope cutthroat trout. A second lake, Black, showed marked improvements in the percentage of westslope cutthroat genes between 1986 and 1994. A test in 1999 indicated that the population continued to improve, reaching 99% westslope. Some major detectability issues have come to light in the Black Lake example. For instance, from 1991 to 1994, four separate genetic tests were conducted and no Yellowstone cutthroat trout genes were detected. In 1999, Yellowstone cutthroat genes were detected, and rainbow genes were not. Unfortunately, in 2001, the presence of Yellowstone cutthroat was re-detected and the entire population was reported to be a hybrid swarm, meaning that each fish carried the exotic genes. Although this may not be a direct implication of genetic swamping, it suggests that the dramatic changes in the population may require the full time frame to accurately measure the progress of the lake populations. Some have argued that sampling a population so soon after stocking increases the risk of catching genetically pure fish that came directly from the hatchery. Rather, the best way of evaluating a population would be to allow more time for the hatchery fish to influence the hybrid population, thereby avoiding bias of sampling pure hatchery fish.

Since 1985 genetic swamping has improved the genetic status of many lakes in the South Fork Flathead drainage. However, there may be other reasons why this promising tool may need to be deferred in favor of a more conclusive method. Primary among these is the extended time frame required to implement this method. Genetic swamping in the South Fork Flathead began in 1985. Based on the original time estimates, an additional 17 to 23 years may be necessary before it is completely effective. Next, there are two major assumptions that must be met in order for swamping to be effective. First, there must be some form of natural reproduction in each lake to facilitate hybridization, and second, this reproduction must occur each year in order to meet the 20-40 year time frame. Variation in year class strength, fish health and condition, random mating, and weather patterns all influence the effectiveness of natural reproduction and ultimately hybridization for genetic swamping purposes. Finally, there is a concern that stocking high numbers of fish in the project lakes may cause exotic trout to be displaced downstream (Hull 1986). Downstream movement of exotic trout is precisely what this project is aimed at eliminating. For these reasons it has not been developed further as a preferred alternative.

Gill netting

This method is considered a passive capture technique to collect fish by entangling or ensnaring (Hubert 1992). Both gill nets and trammel nets are arrangements of mesh that capture fish when they swim into it. Most often fish bodies become wedged or their teeth get entangled in the net. Nets are typically made of cotton, nylon or monofilament fiber and mesh sizes can range from ½ inch for small fish to 5 inches for larger species like paddlefish. The method has been used successfully to remove unwanted fish from lakes and reservoirs. Bighorn Lake, a 5.2 acre lake located in Banff National Park in Alberta, Canada, was gillnetted from 1997 to 2000 to remove an unwanted population of brook trout (Parker et al. 2001). Over 10,000 net nights (1 net night = 1 net set overnight for at least 12 hours) were conducted over a four year period in Bighorn Lake to remove the population which totaled 261 fish. The rersearchers concluded that the removal of nonnative trout using gill nets was impractical for larger lakes (> 5 acres). In clear lakes, trout have the ability to become acclimated to the presence of gill nets and to avoid them. These researchers reported observing brook trout avoiding gill nets within about 2 hours of being set.

Knapp and Matthews (1998) reported that Maul Lake, a 3.9 acre lake in the Inyo National Forest in California, was gill netted from 1992 to 1994 to remove a population of brook trout. The population, which totaled 97 fish, was successfully removed with an effort of 108 net days. The researchers reported that following the removal of brook trout from Maul Lake it was mistakenly restocked with rainbow trout. Efforts to remove them using gill nets were implemented immediately. From 1994 through 1997, 4,562 net days were required to remove the 477 rainbow trout from the lake. These researchers reported that gill nets could be used as a viable alternative to chemical treatment. They acknowledged that the small size and shallow depth of Maul Lake leant itself to a successful fish eradication using gill nets. Their criteria for successful fish removal using gill nets include lakes less than 3.9 surface acres, less than 19 feet deep, with little or no inflow or outflow to perpetuate reinvasion, and no natural reproduction. Although not tested, the maximum size of a lake that they felt could be depopulated using gill nets was 7.4 surface acres and 32 feet deep. The only lakes in this project that meet these criteria are those in the Necklace chain of lakes.

Selective gill netting has been used in Yellowstone Lake, Yellowstone National Park, Wyoming in an attempt to control the lake trout population since 1995. From 1995 through 1998 approximately 20,000 lake trout were removed from Yellowstone Lake by gillnets. From 1999 to 2001, over 15,031 net nights were necessary to collect approximately 24,500 lake trout (YCR 2001).

There are a multitude of reports that describe the role of gill nets in reducing overpopulated rough fish (Meronek et al. 1996). Reil (1965) reported that five successive years of intensive gill netting were required to only reduce the overpopulation of yellow perch in Bow Lake, New Hampshire. Gill netting for commercial enterprise has been responsible for the collapse of many fisheries throughout the United States and Canada and includes species like lake trout, walleye, cisco and lake whitefish. Mitchell and Prepas (1990b) reported that many years of intensive commercial gillnetting of Touchwood Lake, Alberta eliminated lake trout from the lake. Attempts to re-establish a population since 1967 have been unsuccessful. Several other species are still present in the lake and the commercial fishery reportedly continues to harvest an average of 44,000 pounds of fish per year. Mitchell and Prepas (1990a) reported that intensive gillnetting of Lesser Slave Lake, Alberta prior to 1940 eliminated the lake trout population. Subsequent high intensity commercial netting for walleye, cisco and whitefish caused those fisheries to collapse in the 1960's and 1970's. They have since recovered.

The Montana Bull Trout Scientific Group concluded that gill netting would not result in a complete removal of fish that compete with bull trout (MFWP 1996). Rather, they recommended that it be used as a suppression technique. In very specific circumstances this method could lead to total removal.

Diving ducks and some raptors have been observed at some of the lakes (scaup, osprey). Operating gill nets for extended periods of time increases the possibility that diving ducks and fish eating birds would themselves become entangled in nets when they try to capture fish caught in nets.

Targeting concentrations of fish during spawning periods is one technique that could increase probability of success using gill nets (Reil 1965). However, sheets of ice are often present in many high altitude lakes during normal spawning periods. Some lakes have been observed to have large rafts of ice present as late as mid July. This would make setting and checking gill nets during spawning times difficult, if not precluded. Westslope cutthroat trout typically spawn in June. Spawning is often delayed in high altitude lakes because of cold water temperatures and ice conditions. Because westslope cutthroat do not sexually mature until about three years of age, at any give time, there are at least two year classes of fish that would not be present at spawning areas. This would require returning to the spawning sites at least two more years to attempt to capture fish as they are becoming sexually mature and attempting to spawn. These factors further complicate the use of nets as a method to remove fish from high altitude lakes.

Despite the success of gill nets at removing fish from small mountain lakes and from large lakes during commercial operations, there are several reasons why this method would not be appropriate or practical for the lakes listed in this proposal. First, the intensive effort required to accomplish this goal, even on small lakes, has demonstrated it to be an inefficient method. Although commercial netting operations on large lakes have been responsible for the reduction and/or elimination of certain species of fish, it has required many decades to accomplish this. Commercial scale gill netting operations are dependant on large vessels to set and pull nets, and to process the catch. This would require boats, operators and camp to be present at these remote lakes for an extended period of time. Setting and pulling of gillnets could be accomplished using a helicopter with floats, but would require a high number of flights over many years to retrieve and set nets on each lake. Second, leaving nets unattended provides an opportunity for vandalism and theft. As recently as 2001 MFWP had a gill net stolen from Wildcat Lake in the Jewel Basin Hiking area during an overnight netting operation. Next, given the long-term commitment required for gillnetting to remove fish, each lake would be without quality angling for several years. Next, gill nets are reported to be highly selective in capture efficiency based on fish size (Hubert 1992). Gill netting, in general, captures very few small fish. Finally, gill netting could not be used to remove fish from a stream (MFWP 1996).

For these reasons, the use of gill nets to completely remove fish from the lakes and streams was not considered to be a practical alternative and the method was not developed further.

Seining

This method of fish sampling is considered an active capture method that involves the use of a long fence-like net to encircle fish and draw them into the shoreline for collection (Hayes 1992). The top edge of the seine has floats attached to keep the net upright in the water, and the bottom edge of the net is weighted to keep it on or near the bottom. There are several types of seines for applications that have varying water depth, rocky bottom or mud bottom, large fish or small fish. These include bag seines, purse seines, minnow seines, beach seines and lampara seines. To deploy a seine, one end is attached to or held by a person on the shore of a lake, pond, or river and the other end is stretched out into deeper water while forming a “U” shape with the net. In a lake a boat is used to stretch the seine into deeper water. The seine is gradually pulled into the shore to reduce the area of the “U” or “bag” and the fish are gradually concentrated where they can be removed by dip netting or by pulling the remainder of the seine on shore.

Factors that interfere with the capture efficiency of a seine include obstructions like submerged trees, rocks, aquatic plants, flowing water, uneven lake bottom, and steep banks. Seines have been used successfully to remove fish for commercial harvest. Warnick (1977) reported that commercial seining has been instrumental in providing about 80-85% of the 20-30 million pounds of carp commercially marketed annually in the United States. Under-ice winter seining in South Dakota was reported to be far more effective for this type of operation, but seining under the ice is seldom employed for fisheries management purposes.

Ricker and Gottschalk (1940) reported that seining was used to greatly reduce rough fish numbers, which improved game fishing in Bass Lake, Indiana. From 1935-36, 142,000 pounds of carp, buffalo and quillback were removed from the lake by seine and subsequent surveys on game fish revealed an improvement on game fish size and abundance. The authors reported that although the Bass Lake experiment was successful, similar attempts made on many other lakes ended in failure partly because of the scarcity of suitable beaches for seining.

Rose and Moen (1952) reported that 12 years of aggressive seining on Lake Okoboji, Iowa yielded nearly 2.5 million pounds of rough fish. Seining on this lake could not totally remove all of the rough fish even when accompanied by gill netting and trapping over an extended period of time.

The use of seines to remove exotic trout from the proposed lakes was examined and found to be impractical for several reasons. The three major papers cited for this sampling methodology employed large seines measuring up to 2500 feet in length. Although complete removal was not listed as an objective, the intensive effort only reduced the number of target fish and they were never completely removed. The amount of time necessary to effect a complete removal would require many years, which is similar to other methods of mechanical removal. A large crew with boat would be required to be at each lake for an extended period of time. Given the remote nature of the lakes, long-term operations would have a negative impact on the aesthetics of the lakes. The general lack of gradual beaches and snag free shorelines makes depending on seining an impractical method. Although seining is used successfully to capture fish in larger rivers and low gradient streams, it would not be a practical method to remove fish from small high gradient streams. For these reasons seining was found to be ineffective at complete fish removal and was not developed further as a viable method.

Trap nets

Traps are considered a passive method of fish capture (Hubert 1992). Trap nets most commonly used are hoop nets and fyke nets. Hoop nets typically consist of five hoops and frames with netting stretched around them and a mesh funnel on one end that directs fish into the net. A typical size would have a series of 3-4 foot diameter hoops and stretch to about 20 feet in length. Fish that enter the trap are funneled into the cod end, which is a communal holding area. A hoop trap would hold fish alive for an extended period of time until a fishery worker empties it. A motorized boat is mandatory for setting the trap. The trap may be emptied by pulling it to shore, or by lifting it into a boat. Hoop nets are often baited to attract fish. Hoop nets are highly selective for migratory species and species that that are attracted to bait and cover. For these reasons they can be selective in what species they will catch.

Fyke nets are similar to the hoop net with the exception of having a long net called a "lead" or "fence" attached to direct fish into the funnel. This lead can range in length of 50 to 200 feet. The trap lead is staked on the shoreline of a lake and the entire lead and net is stretched perpendicular to the shore. Fish swimming along the shoreline encounter the trap lead and swim into deeper water to get around the obstacle. In doing this, fish swim into the funnel and ultimately reach a communal holding area at the cod end of the trap. Fyke nets are selective for what species of fish they will capture and work best with species that are mobile and orient to cover.

The vast majority of literature concerning trap netting for fish removal had objectives to only reduce the number of stunted or overpopulated rough fish, bluegills, perch, bass and crappie (Meronek et al. 1996), or they were used in combination with other methods (Rose and Moen 1952). The compendium of literature evaluated demonstrated that an incredible amount of effort was required to only reduce the number of fish in these lakes. Grice (1957) reported the results of fyke netting on several Massachusetts waters. Indian Lake (172 acres) was fyke netted from 1954 to 1956 and 19,300 pounds of panfish and rough fish were removed. Jordan Pond (20 acres) was fyke netted from 1953 through 1955 and 5,700 pounds of fish were removed. Netting did not completely remove all the fish from the water bodies.

Targeting spawning areas and capturing fish when they are concentrated is one technique that could increase probability of success using traps (MFWP 1996). However, limitations to this method are similar to other netting methods in that sheets of ice are often present in many high altitude lakes during normal spawning periods. Some lakes have been observed to have large rafts of ice present as late as mid July. This would make setting and checking trap nets difficult, if not precluded. Westslope cutthroat trout typically spawn in June. Often times spawning is delayed in high altitude lakes because of cold water temperatures and ice conditions. Because westslope cutthroat do not sexually mature until about three years of age, at any given time, there are at least two year classes of fish that would not be present at spawning areas. This would require returning to the spawning sites at least two more years to attempt to capture fish as they are becoming sexually mature and attempting to spawn. These factors further complicate the use of traps as a method to remove fish from high altitude lakes.

The Montana Bull Trout Scientific Group concluded that trapping would not result in a complete removal of fish that compete with bull trout (MFWP 1996). Rather, they recommended that it be used as a suppression technique. In very specific circumstances this method could lead to total removal.

A motorized boat would be required to set and check trap nets, and a camp would be required at each lake to house personnel for an extended time period for this type of operation. Shallow water and gradual sloping shorelines and banks are required for efficient operation of trap nets (Hubert 1992). Despite occasional sets in steep rocky terrain on Tongue River Reservoir, Montana for collection of walleye, fishery workers have reported that this type of set often yields few fish and nets have a tendency to roll during deployment which fouls their capture efficiency. Many, but not all, lakes listed in this proposal have steep rocky shorelines. Finally, trap nets could not be used to effectively remove fish from small high gradient streams. For these reasons, the use of traps to remove exotic trout from these high altitude lakes was considered impractical and not developed for further consideration.

Electrofishing

This method is considered an active capture technique, which involves introducing an electric current into the water (Reynolds 1992). The electricity causes an involuntary muscle contraction in fish and attracts them to the source of the electricity (electrode) where an attendant nets them. Afterwards the fish revive within about

30 seconds. Electrical variables like voltage, amperage, pulse frequency and waveform are manipulated to achieve the desired response by fish. Environmental conditions like water temperature, water clarity, water conductivity, and substrate influence its effectiveness. Species of fish, fish behavior, time of year, and time of day are all variables that play a vital role in the effectiveness of electrofishing. Electrofishing works best in shallow water (Reynolds 1983). It is most commonly used to sample fish in rivers and streams, but is occasionally used to sample the shallow water zones of lakes.

The area of coverage of a typical electrofishing boat has been measured and described by Grisak (1997) to be about 2 meters. The use of electrofishing for population surveys in the Flathead Basin is conducted almost exclusively on small streams. The primary reason for this is that glacial water is low in conductivity, which does not allow for efficient distribution of electrical current to facilitate fish capture. Small streams have a reduced area for fish to hide and therefore lend themselves to better fish collection under low conductivity conditions. In deeper water of rivers and lakes however, electrofishing is not an efficient means of fish capture, especially in low conductivity clear water. In high altitude lakes in the Flathead, electrofishing would need to be conducted at night to offer the greatest probability of capture. Using this method, there is one assumption that for it to be 100% effective every fish in the lake would have to swim into the shallow zone of the lake, during the time the electrofishing operation is being conducted. Because electrofishing in a lake is limited to the shoreline, one disadvantage is that there is ample space for fish to escape the electric field.

Electrofishing a high altitude lake in the Flathead, would require a large motorized boat approximately 14-17 feet long, two operators, a 5000 watt generator, a large water tank, rectifying unit, nets and miscellaneous equipment. Inflatable rafts have been retrofitted with electrofishing systems and used to sample rough rivers, but this type would not be feasible in a lake. In low conductivity water, larger electrodes are valuable at creating a larger electrical field, but still do not penetrate much beyond 2 meters of depth. In many electrofishing operations in Montana, the hull of the boat is constructed of metal and serves as the negative electrode. Other boats, made of fiberglass or plastic, employ an external negative electrode, but these are rarely used in lakes and are used in areas where water conductivity is much higher than in the Flathead basin. Because the water is very clear, the operation would need to be conducted at night. The boat would need to be transported to the site with a large helicopter. Because of the extended period of time required for mechanical removal of fish, a boat and operators would need to stay camped at the lake for an extended period of time. An outboard motor and 5000 W generator would need to be operated for 5-8 hours each night. The operation would involve conducting multiple electrofishing passes along the shoreline for most of the dark hours each night.

Numerous attempts have been made to remove unwanted fish using electrofishing, but this has occurred mostly in streams. MFWP conducted an electrofishing removal of brook trout from 6 km of stream above a barrier on Muskrat Creek (Shepard et al. 2001). Over a four year period, researchers electrofished 5,386 brook trout from this section and moved them below a barrier. After four years of electrofishing effort, they concluded that the operation was not 100% effective and recommended that some type of fish toxin be used to permanently eliminate the brook trout from the study section.

Targeting spawning areas and capturing fish when they are concentrated is one strategy that could increase probability of success using this method. Large debris and log jams occupy outlets of many lakes where spawning occurs. Shelf ice is still present in outlet streams of many high altitude lakes during normal spawning periods. Some lakes have been observed to have large rafts of ice present as late as mid July. Westslope cutthroat trout typically spawn in June. Often times spawning is delayed in high altitude lakes because of cold water temperatures and ice conditions. Because westslope cutthroat do not sexually mature until about three years of age, at any given time, there are at least two year classes of fish that would not be present at spawning areas. This would require returning to the spawning sites at least two more years to attempt to capture fish as they are becoming sexually mature and attempting to spawn. These factors further complicate the use of electrofishing as a method to remove fish from high altitude lakes. Cold-water temperatures in many of these lakes makes the window of effective opportunity using electrofishing reduced to about 3 months per year.

Little literature was found that described the use of electrofishing to eliminate fish from a lake. Spencer (1967) reported that AC electrofishing was used to kill excessive numbers of intermediate sized bluegills in experimental ponds while having little effect on largemouth bass. A great number of reports were available on the use of electrofishing to remove or reduce numbers of fish from streams (Shetter and Alexander 1970).

Considerations that make this method less desirable include: the extended amount of time required to facilitate near complete fish removal, poor aesthetics associated with operating a boat with generator and camp at a lake in a primitive area for an extended period of time, low capture efficiency of electrofishing in clear and deep water, low capture efficiency of electrofishing in low conductivity water, and the method is not known to have ever been successful at fulfilling the objectives of this type of project.

Lennon (1970) reported that the greatest use of electricity to control fish has been in the sea lamprey program on the Great Lakes. Because this method involved using an electric field to repel lampreys at weir sites, it is not believed to have a viable application in removing fish from the lakes proposed in this project. For these reasons electrofishing was found to be ineffective at complete removal of fish from the lakes and streams and it was not developed further as an alternative.

Tiger muskellunge

The tiger muskellunge is a highly voracious predatory fish that is created by hybridizing the muskellunge with the northern pike. Hybridization in the wild was first observed in 1937 in Wisconsin (Black and Williamson 1947), and Eddy first reported artificial hybridization in 1941 in Minnesota (Crossman and Buss 1965). The hybrid is considered to be sexually sterile (Stein et al.1981), but some have reported empirical information suggesting fertility in females is possible, and backcross experiments with northern pike have yielded very few viable offspring (Black and Williamson 1947). This fish has been used for management purposes to reduce the number of rough fish in lakes to provide space for more desirable game species (Storck and Newman 1986). Since 1987 MFWP has stocked 53,500 tiger muskellunge in 10 water bodies for species control and diversity of angling opportunity. Most of these fish have been spawned at the Miles City State Fish Hatchery with muskellunge semen imported from Minnesota. Tiger muskellunge prefer soft rayed fish for prey (Tomco et al. 1984). They are territorial fish that tend to stake-out areas of a lake. Recapturing them by trap and electrofishing in Iowa has been difficult (Gengerke 1985). Similar territorial behavior has been reported for Little Warm Reservoir in Blaine County, Montana and in H.C. Kuhr Reservoir in Phillips County, Montana (K. Gilge MFWP, personal communication 2002). This difficulty in recapturing has made evaluating some populations difficult. Although growth is slower in cool water ($<62^{o}$F), survival in cool water at stocking time is better (Lemm and Rotters 1986). Confounding information has been presented in the literature about their value to anglers as a sport fish (Stork and Newman 1986; Wahl and Stein 1993).

If tiger muskellunge were introduced into a lake in the South Fork Flathead they would be allowed to live in the lake until they died of natural causes. Longevity of tiger muskellunge is not reported, but the parental species can live for 24 (northern pike) to 30 years (muskellunge) (Scott and Crossman 1973). Hybrid vigor is reported to be manifested well in this species causing accelerated growth. This suggests longevity of the hybrid may be reduced.

The lack of information regarding the efficiency of tiger muskellunge to capture trout as prey may make them unreliable to carry out the objective of this project. If trout are not sufficiently used by tiger muskellunge as a prey source due to low abundance, behavioral differences, or otherwise, shifts to other prey items by this top-level predator could have devastating effects on the amphibians, reptiles and water birds that occur in these lakes. The parent species of this hybrid are notorious for feeding on frogs, salamanders and ducks (Scott and Crossman 1973). The time necessary for tiger muskellunge to remove trout from a lake would be protracted because the trout in many of the lakes would be reproducing and providing a continual source of fish to the lake. The size of prey selection increases with tiger muskellunge length (Wahl and Stein 1993; Gillen et al. 1981). Given this, proportionately smaller prey would be available to tiger muskellunge in the project lakes, as the predators grow larger. This may confound the efficiency of the predator to remove the exotic trout from the lakes. Schmitz and Hetfeld (1965) reported studies that showed the failure of "the pikes" to secure prey of appropriate sizes resulted in marked reductions in growth. Weithman and Anderson

(1977) reported that the introduction of tiger muskellunge for fish management purposes is conducted to crop underused prey fish, convert it to valuable game fish, and to reduce the density of adult prey species. They reported that the species should be used in reservoirs with a surplus of prey. If the desired outcome of the tiger muskellunge introduction in the South Fork Flathead were to eliminate all exotic trout from a lake, the diminishing food supply would undoubtedly lessen the condition of the predator and ultimately affect its ability to remove all of the fish. Total elimination of exotic trout by tiger muskellunge has not been reported and could require many years to implement. During this time, the trout fishery would be severely impaired, while only marginal angling existed for tiger muskellunge. Introduction of tiger muskellunge into the project lakes would not address the problem of hybrid fish in the outlet streams of some lakes. Finally, using tiger muskellunge to accomplish the goals of this project would require the introduction of a new species in a federally designated wilderness area, and in waters that have federally endangered bull trout lower in the drainage. For these reasons, the use of tiger muskellunge was determined to be impractical for complete removal of fish from the lakes and streams and was not developed further as a viable alternative.

Other hybrid species considered during this evaluation include *saugeye* (walleye x sauger) and *splake* (lake trout x brook trout) but were considered impractical, primarily because these hybrids are sexually fertile (Scott and Crossman 1973).

Chemical removal

The use of toxicants for sampling or removing fish populations is a common practice, particularly in impounded waters and streams in the southeastern United States (Davies and Shelton 1992). Lennon et al. (1970) reported that as of 1970, 29 countries including the United States and Canada were actively using fish toxicants to control species of undesirable fish. Fish toxicants have been used for complete removal of fish, partial kills for population surveys, for selective removal of certain species, and in commercial fish farming. Although over 30 toxicants have been used, the most common are antimycin and rotenone. The following information details the fish toxins that are considered for use in this project.

<u>Antimycin</u>

This compound is an Environmental Protection Agency (EPA) registered chemical (No. 39096-2) under the brand name Fintrol®. It was first discovered in 1945 at the University of Wisconsin as an antifungus treatment for plants (Leben and Keitt 1948). It is a product derived from the fermentation of a species of *Streptomyces* bacteria (Nick Romeo, Aquabiotics, personal communication, 2002). It has been used in Japan for the control of fungus on rice (Harada et al. 1959), and is an extremely potent fungicide (Dunshee et al. 1949). Antimycin works by inhibiting cellular respiration only in selected organisms. In 1963, Derse and Strong found that it was extremely toxic to fish, in much lower concentrations than typically used to control plant diseases. It has been used for over 35 years in commercial aquaculture to kill scaled fish in catfish ponds (Finlayson et al. 2002). Walker et al. (1964) reported that trout were extremely sensitive to antimycin. When fish absorb antimycin through their gills, it interferes with oxygen transfer at the cellular level (Derse and Strong 1963). Fish are sensitive to antimycin because their gill membranes are only one cell layer thick, which allows for quick transfer into the blood stream and ultimately it disrupts the electron transfer at the cellular level in vital organs (Schoetteger and Svendsen 1970). This is accentuated in trout because their breathing style (ram ventilation) requires a high volume of water to move across their gills either by flowing stream water, or by swimming quickly in a lake. Different species of fish have different resiliency to the compound.

Antimycin is generally insoluble in water and must be emulsified with acetone and detergent. Once it is dissolved, the toxic effects on trout, administered at 1 to 10 ppb (parts per billion; 1 ppb = 1 part antimycin to 1 billion parts water) can be realized in as quickly as 1 hour (Walker et al. 1964, Gilderhus 1972). Concentrations most commonly used in streams and lakes range from 2-20 ppb and applicators have reported seeing dead trout within 1.5-2 hours of exposure during field trials (Rabe and Wissmar 1969; Stefferud et al. 1992; Gresswel 1991). This rate is influenced mostly by pH (Marking 1975, 1973), second by water temperature, then by ultraviolet light. Water hardness does not appear to be a major influence in its efficacy.

Antimycin is shipped by the manufacturer in two parts; one is the active ingredient antimycin A with some residual fats, and the second is the surfactant which consists of acetone and detergent. Each component consists of 240 milliliters (ml) of solution and when combined are called a “Unit” which is 480 ml. Often times a small amount of detergent is added to keep the solution from clogging dispensers in cool weather (<70^{o}F). The weight of one unit, including the added detergent, is 3.75 pounds.

The physical properties of antimycin make it beneficial for site-specific application. When applied to a stream it looses much of its toxicity with every 200 feet of downstream elevation drop (Tiffan and Bergersen 1996; Nick Romeo, Aquabiotics, personal communication, 2002). It detoxifies to sub lethal levels because of the oxidation action created by a turbulent stream as well as its interaction with organic substances on the stream bottom. Numerous applicators have described the need to install drip stations at 200-foot elevation intervals to recharge a stream with antimycin. This property makes it an attractive tool in areas where a lake population is targeted and downstream populations are not. Non-target fish populations that occur downstream of a lake treated with antimycin may be safeguarded in this manner if this 200-foot elevation differential is met. In areas where non-target populations are within the 200-foot elevation zone, potassium permanganate administered at 1 ppm (parts per million; 1 ppm = 1 part potassium permanganate to 1 million parts water) has been used to detoxify antimycin (Stefferud et al. 1992; Gilderhus et al. 1969). Marking and Bills (1975) reported that antimycin exposed to 1 ppm potassium permanganate had a half life of between 7 and 11 minutes and is rapidly detoxified by 1 ppm potassium permanganate in waters of pH 6.5 to 9.5. Berger (1966) reported that 1ppm potassium permanganate was used to neutralize 10 ppb antimycin.

Other compounds that will readily bind with antimycin to detoxify it include activated charcoal and natural substances like leafy vegetation and water plants. It does not enter ground water supplies because it binds rapidly with organic compounds in soil and in water (Nick Romeo, Aquabiotics, personal communication, 2002).

Water temperature has an influence on the efficacy of antimycin (Walker et al 1964, Gilderhaus et al. 1969, Marking and Dawson 1972). Longer exposure times are required in colder water to produce mortality in trout (Tiffan and Bergersen 1996). For this reason, antimycin will naturally detoxify quicker in warmer water than in colder water. Water treated at 39^{o}F required two to three times as much exposure time for mortality than water treated at 71^{o}F (Lee et al. 1971).

Antimycin degrades rapidly in water and detoxification under field conditions can be complete within 24 to 96 hours (Walker et al. 1964; Lennon 1970). Sunlight will also break down antimycin. Lee et al. (1971) reported that when in aqueous solution in sunlight and shade, it had a half life of less than 20 minutes.

Marking (1973) reported that the performance of antimycin decreases dramatically when the pH of the water is over 8.5. The pH values measured from lakes in this project are fairly consistent. The mean pH value for project lakes is 6.8 and ranges from 6.2 to 7.7 (see Table 6 for listing of some values). Based on this information antimycin would be expected to perform at it’s most effective level under these water conditions.

Based on half life toxicity studies conducted by Marking (1973, 1975), Marking and Dawson (1972) and Berger (1966), and the measured pH values of lakes proposed in this project (range 6.2-7.7), the expected toxicity of antimycin to fish in the project lakes would last for 2-7 days. This rate would be slightly influenced by water temperature and sunlight intensity during the application. Trout are highly sensitive to antimycin. Contact time necessary to cause death ranges from 1-4 hours and the effects are irreversible (Gilderhus et al. 1969; Gilderhus 1972). Rosenlund and Stevens (1992) reported that this time is actually protracted during field applications but once exposed, trout are usually dead within 48 hours. Because fish cannot taste or smell antimycin, the compound does not repel fish like other toxicants can (Lennon 1970; Berger 1966). For this reason fish do not intentionally avoid exposure to the compound.

There is less danger of transporting antimycin with livestock, or other means, than with Prenfish because antimycin is shipped in two parts and is virtually inert until mixed. With the lack of an emulsifier, an unexpected spill of antimycin in a non-target stream during transport would be ineffective.

Antimycin has been extensively tested to measure its effect on non-target organisms. A compendium of study results on non-target organisms was prepared by Schnick (1974) who concluded that laboratory studies, field trials and reclamation projects revealed that vertebrates, phytoplankton or aquatic plants exposed to antimycin at fish killing concentrations demonstrated no adverse effects either short term or long term. Toxicology studies conducted on certain amphibian species have shown that antimycin is non-toxic at the levels used to kill trout. It has been found to be non-toxic to plankton, bottom insects, water plants and amphibians and reptiles (Walker et al. 1964). Berger (1966) reported that bullfrog tadpoles required doses 5 times (40 ppb) greater than fish killing concentrations to effect lethality, and tiger salamanders required doses 75 times (600 ppb) greater to effect death. Likewise, laboratory studies on newts, frogs, tadpoles, bull frogs, leopard frogs, turtles and snakes have shown that they will survive exposure to antimycin at levels prescribed for trout removal (Schnick 1974). Laboratory tests conducted in Montana in January 2003 found that tailed frog tadpoles and adults were not affected by antimycin at concentrations up to 28 ppb (Grisak 2003). Only at 56 ppb were 11% of the tadpoles affected. This concentration is 8 times greater than what is typically administered during fish removal programs. Lesser (1970) reported it was not toxic to crayfish or clams, but was to freshwater shrimp. Callaham and Huish (1969) reported that zooplankton were severely depleted but began to reappear within 6-9 days and bottom insects were not affected by antimycin. Hughey (1975) concluded that 4 Missouri ponds treated with antimycin showed little short term and no long term effect on population levels of zooplankton. The effects of antimycin on plankton were consistent with the natural variability that is characteristic of plankton populations, and re-colonization was rapid and reached near pre-treatment levels within 8 months.

Antimycin threats to animal and human health have been studied extensively. Ritter and Strong (1966) measured accumulation levels of antimycin in muscle, kidney, liver, heart, gill and skin of several fish species. The range of values of antimycin absorbed by fish was 4-10% of that administered into the water. Mammals and birds required much higher concentrations to effect death. Using these data, the authors calculated that a 4-ounce serving of fish containing 201 micrograms of antimycin per kilogram (µg/kg) would provide 23 µg of antimycin or 0.33 µg/kg for a 150 pound human. A dose of even 1 milligram per kilogram (mg/kg) (100 times as much), would require a human to eat 3,000 four-ounce servings; the equivalent of one serving per day for 8.2 years. Twenty-one humans associated with this study consumed from one to five such servings and suffered no ill effects. They concluded that antimycin-killed fish would be safe as human food. Schnick (1974) reported that antimycin is not hazardous to humans whether it is consumed in water or food.

Antimycin was used successfully in 26 Colorado lakes and streams from 1973 to 1990 to remove exotic trout from alpine areas (Rosenlund and Stevens 1992). These efforts were conducted for the restoration of the Colorado River cutthroat trout and the greenback cutthroat trout within the Rocky Mountain National Park. In 1989 authorization was given (Cargill and Buterbaugh) and the Rock Creek project was implemented at the Leadville National Fish Hatchery, Colorado to remove non-native trout and replace them with greenback cutthroat trout (Rosenlund 1989). The project occurred in the Mount Massive Wilderness and involved applying antimycin to Rainbow Lake, Native Lake, Swamp Lake, and most of Rock Creek.

In 2001 antimycin was used in Great Smokey Mountains National Park, Tennessee to remove non-native rainbow trout from Sam Creek and Starkey Creek (Moore et al. 2001). The purpose was for restoration of native brook trout. In 1974, President Ford approved designation of approximately 425,000 acres of the Great Smokey Mountains National Park as federal wilderness under DES-74-104 (Moore 2002) in which Sam and Starkey creeks are located. The park is managed as de facto wilderness. Antimycin was used successfully in Sun Creek in Crater Lake National Park, Oregon to remove brook trout that were hybridizing with native bull trout (Buktenica 1997).

Prior to the application of antimycin each lake would be thoroughly surveyed to identify the volume of the lake, identify the number and location of water inflows and outflows and estimate or measure their flow rates, measure water chemistry and temperature, collect plankton samples, and conduct an amphibian survey (Maxell 2002). Lake volume is calculated through a series of depth measurements and GPS (global positioning system) locations while in a raft on the lake. At each GPS location, depth is recorded. These data are subsequently superimposed on an image of the lake surface to correct for boundary errors. The data are then entered into a computer program called TIN (triangulated integrated network), which uses the GPS and depth data to create volumetric layers within the lake surface image. The program constructs a three-dimensional lake basin as a map. From this three-D image, the program calculates the lake volume. Using this volumetric information, MFWP personnel can calculate the proper amount of antimycin needed to eliminate fish from the lake. The antimycin must be applied at the proper concentration to treat the lake successfully. All calculations would be double-checked for accuracy.

The stream system that flows out of the lake is surveyed to determine volume and flow rate using standard US Geological Survey methods. From this, important factors for dilution and detoxification can be made. Also, cursory experiments using potassium permanganate are implemented to determine the organic demand of a stream so that any detoxification measures would ensure antimycin is properly neutralized if necessary.

Before application, MFWP must apply for and secure a 308 permit from the MDEQ. This permit allows for short-term exemptions of Montana's surface water quality standards.

Most treatments would occur from mid-September to early October, depending on other activities in the area (e.g., spawning seasons, bull trout surveys, and hunting) and depending on weather conditions.

Since no applications of antimycin have been conducted in a Flathead basin lake, fisheries personnel having this expertise would be on site and act as the consulting project leaders for the first application. Thereafter, trained personnel in the area would conduct the application. A Montana Department of Agriculture licensed applicator would be on site to supervise all applications according to Montana guidelines. For each project, an application plan would be developed to direct the activities and responsibilities of all personnel involved. Because antimycin can be a skin irritant, protective clothing, eye protection and respirators are required during mixing and application.

Roselund and Stevens (1992) have described in detail the procedures for implementing a successful antimycin project. They reported that an outboard motor is absolutely necessary to obtain an effective mix of antimycin during a lake application. Because it is applied in such low concentrations, the compound requires thorough mixing. If an outboard motor cannot be used, they recommended not conducting the treatment. Application begins by administering the compound by boat using a bilge pump and a venturi suction mechanism fitted to the outboard motor. In lakes that are greater than 30 feet deep, the pump would be used to administer the compound in deep water using a weighted hose of appropriate length. The recommended concentrations for lake application range from 1 ppb (Derse and Strong 1963) to 10 ppb (Gilderhus et al. 1969) depending on the species of fish. It has been used successfully to remove trout from high altitude lakes in Rocky Mountain National Park at concentrations of 5-8 ppb (Rosenlund and Stevens 1992). The target concentration for lakes in this proposal is 7.5-8 ppb. Water chemistry would be the most influential factor in determining this concentration and would be measured prior to application to ensure proper concentration.

Application by motorized raft begins in concentric rings around the shore and continues inward until the entire lake surface has been treated. Afterwards, if necessary, the treatment of deepwater zones greater than 30 feet would be conducted until finished. If necessary, during the application on the lake by raft, personnel would install and monitor drip stations to treat flowing fish habitats that enter and exit each lake. Larger lakes would require multiple motorized rafts to ensure the application is completed within one day. On projects that require removing hybrid fish from downstream, drip station monitors would be stationed at intervals approximately every 200 feet in elevation drop along the outflow stream to administer booster doses of antimycin. Drip stations would consist of poultry waterers with a hole drilled in the bottom to dispense the appropriate concentration of antimycin for 8 hours. At the lower boundary of the treatment project, a monitor would have caged fish in the stream to measure toxicity. At this site a detoxification station would be on hand ready to dispense potassium permanganate neutralize the antimycin if necessary. Using a colorimeter to measure potassium permanganate, field tests would be conducted the day before the application to determine the potassium permanganate demand of the particular stream to ensure proper detoxification, if necessary (Engstrom-Heg 1971,1976). Caged fish would be monitored for 48 hours after the application.

The two days following the application, dead fish would be cleaned from the lakeshore, taken to deeper water and sunk. This serves to prevent dead fish from becoming an attractant to predators, improve aesthetics at the site, and to stimulate primary production in the lake. To the extent possible, dead fish would be removed from the streams following the treatment.

For each water body treated, the certified applicator submits a Montana Department of Agriculture - Record of Application Report that describes, among other things, the type and amount of pesticide applied, the area treated, application rate, equipment used, possibility of a complete kill, water conditions at the time of treatment, and detoxification measures, if any.

Lakes that would be treated with antimycin would be without a fishery for up to 2 years following the treatment. Klein (1960) reported that fishing was impaired for two years in two high mountain lakes in Colorado following a rotenone treatment. Restocking of most of the lakes would occur the following July and continue for two more years until a population has been established. Some lakes would be restocked with multiple sizes of fish in an effort to restore the fishery as quickly as possible. Fish of catchable size would not be available to anglers until the second year after the treatment. Tom-Tom Lake and Whale Lake in Montana were treated with formulated rotenone in 2000, and then stocked with multiple sizes of fish 9 months after the treatment. Within 5 days of Whale Lake being stocked, anglers had reportedly caught fish. Angling of Tom Tom Lake in 2002 revealed the fishery had been restored. Before stocking, a gill netting survey would be conducted to determine if any fish might have escaped the treatment. If necessary, the lake would be treated a second time to remove those fish before stocking.

Some lakes listed in this proposal have bull trout populations downstream of them which need to be safeguarded from any chemical treatment. Most of these lakes occur in the Bob Marshall Wilderness. All of the lakes that occur in the Bob Marshall Wilderness section of this project could be treated with antimycin. Only a few of the non-wilderness project lakes have bull trout populations immediately downstream. In these instances, the natural detoxification properties of antimycin would be beneficial in safeguarding the bull trout. Other lakes have downstream populations of hybrid trout that are targeted for removal.

Rotenone

Rotenone is a compound registered with the EPA that is used to remove undesirable fish from bodies of water. This compound is extracted from the roots of tropical plants like the jewel vine and lacepod (*Derris* and *Lonchocarpus* species)(Finlayson et al. 2000; Ware 2002), among others. These roots have been used for centuries by South American natives for a variety of purposes including capturing fish for food (Gleason et al. 1969; Teixeira et al. 1984). It was first isolated in 1895 and its chemical structure was established in 1933 (Haley 1978). Fish managers in North America began using rotenone to manage fish populations in the 1930's and by 1949, 34 states and several Canadian provinces were using rotenone routinely for management of fish populations (Finlayson et al. 2000). Rotenone has also been used as a natural insecticide for gardening and agricultural purposes. Haley (1978) reported that it has been used in humans to control intestinal worms. Rotenone acts by interfering with cellular respiration in gill-breathing animals. The compound is believed to be so successful on fish because it is quickly assimilated into the blood stream through the single cell layer of the gills. Formulations of rotenone products used in fisheries management include Noxfish®, Nusyn-Noxfish®, and Prenfish®, among others. Formulations typically contain 2% to 7% actual rotenone, depending on the brand, approximately 10% is associated resins, and 85% is inert ingredients that make the compound soluble in water. It is manufactured and shipped in two different forms; powdered and liquid. In liquid form it weighs 9.8 pounds per gallon. The powdered formulation weighs 2.03 pounds per gallon (dry) and generally consists of 7.4% active ingredient, 11.1% associated resins, and 81.5% inert ingredients. Typical dosages of rotenone-based formulations, administered to kill fish, range from 0.5 to 6 parts per million (ppm, 1 ppm= 1 part of formulation to 1,000,000 parts of water) depending on the species (Gilderhus 1972; Grisak et al. 2002; Finlayson et al. 2000). Dosage is species dependant due to resistivety of the compound. Trout typically require low dosages of 0.5-1 ppm whereas carp and bullheads require dosages of 4-6ppm. Both fish and aquatic invertebrates (Rach et al. 1988) are highly susceptible to rotenone. Bills et al. (1988) reported that no rainbow trout eggs died from exposure to rotenone.

Rotenone naturally degrades within one to four weeks depending on pH, water temperature, alkalinity, UV light and dilution by fresh water (Schnick 1974). Detoxification may be hastened with the addition of a neutralizing agent like potassium permanganate (Engstrom-Heg 1971, 1972, 1976). The toxic effects of rotenone, on some fish, can be reversed; depending on how much is absorbed. Grisak et al. (2002) reported that fish exposed to 0.25 ppm Prenfish for 12 hours could be revived and survive with no apparent negative effects. "Inert" (i.e., non-lethal) ingredients are added to formulated rotenone to ensure that the active ingredient disperses throughout a given body of water (Skaar 2001). In a study conducted by the State of California (CDFG, 1994), researchers found the following inert ingredients: trichloroethylene (TCE), naphthalene, 2-methylnaphthalene, and xylene.

In 2002 MFWP conducted fish bioassays using Prenfish to identify lethal doses of the compound, and to select appropriate concentrations for application in trout waters in the Flathead basin (Grisak et al.). Bioassays revealed that 1 ppm caused 100% death to westslope cutthroat trout in 2 hours, and 0.75 ppm caused 100% death in 4 hours. Based on these findings, the target concentration for Prenfish applications to remove trout in the Flathead Basin would range from 0.75 to 1ppm. At 1 ppm concentration, one gallon of liquid would cover 3 acre feet of water (Prentiss Incorporated 1998).

There are three ways in which rotenone can be detoxified once applied. The most common method is to allow natural breakdown to occur. Rotenone is a highly unstable compound and a variety of factors influence natural breakdown including water chemistry, water temperature, exposure to organic substances, exposure to oxygen, and sunlight intensity (Ware 2002; ODFW 2002; Loeb and Engsrtom-Heg 1970; Engstrom-Heg 1972; Gilderhus et al. 1986). Rotenone persistence studies by Gilderhus et al. (1986) and Dawson et al. (1991) found that in cool water temperatures of 32 to 46^{o}F the half-life ranged from 3.5 to 5.2 days. Gilderhus et al. (1986) reported that 30% mortality was experienced in rainbow trout exposed to degrading concentrations of actual rotenone (0.004 ppm) in 46^{o}F pond water 14 days after a treatment. By day 18 the concentrations were sub lethal to trout. The second method for detoxification involves basic dilution by fresh water. This may be accomplished by fresh ground water or surface water flowing into a lake or stream. Trout toxicity threshold experiments conducted in Montana (Grisak et al. 2002) suggest that with at an application concentration of 1 ppm Prenfish, dilution of approximately 3 fold is necessary to detoxify. To calculate the dilution by freshwater inputs applicators must measure the amount of Prenfish-treated water being discharged, as well as the amount of freshwater inputs being added to the treated water. The following formula allows applicators to empirically calculate the final concentration of Prenfish downstream of freshwater inputs:

$$C_f = \frac{(C_o \times Q_o)}{Q_f}$$

where C_f is the final concentration of Prenfish in the water, C_o is the original concentration of Prenfish in the water, Q_o is the discharge of the stream at the point of origin (C_o), and Q_f is the final discharge of the stream after freshwater inputs. Factors that would further reduce this dilution ratio would include exposure to sunlight, interaction with organic materials on lake and stream bottoms, and oxidation by stream flow. The final method of detoxification involves the application of an oxidizing agent like potassium permanganate. This dry crystalline substance is mixed with stream or lake water to produce a concentration of liquid sufficient to detoxify the concentration of Prenfish applied. Detoxification is accomplished after about 20-30 minutes of mixing between the two compounds (Prentiss Inc. 1998). The details of potassium permanganate as a detoxifying agent are described in a later section.

Numerous studies indicate that rotenone has temporary or minimal affects on aquatic insects and plankton. Anderson (1970) reported that comparisons between samples of zooplankton taken before and after a rotenone treatment did not change a great deal. Despite the inherent natural fluctuations in zooplankton communities, the application of rotenone had little affect on the zooplankton community. Cook and Moore (1969) reported that the application of rotenone has little lasting effect on the non-target insect community of a stream. Kiser et al. (1963) reported that 20 of 22 zooplankton species re-established themselves to pre-treatment levels within about 4 months of a rotenone application. Cushing and Olive (1956) reported that the insects in a lake treated with rotenone exhibited only short-lived effects. Hughey (1975) concluded that 3 Missouri ponds treated with rotenone showed little short term and no long term effect on population levels of zooplankton. The effects of rotenone on plankton were consistent with the natural variability that is characteristic of plankton populations, and re-colonization was rapid and reached near pre-treatment levels within 8 months.

Both Anderson (1970) and Kiser et al. (1963) reported that most plankter species survive a rotenone treatment via their highly resilient egg structures. In addition, parthenogenesis of some female plankters occurs, causing sexual dimorphism, which greatly increases plankton density in times of population distress. Among the aforementioned studies variation in climate, physical environment, and water chemistry would likely cause subtle differences in results in other areas.

Case studies conducted on Devine Lake in the Bob Marshall Wilderness from 1994-1996 indicate that invertebrates actually increased in number and very slightly increased in diversity following a rotenone treatment (Rumsey et al. 1996). This is supported by observations made by Cushing and Olive (1956), who reported that oligochaetes (worms) increased in number after a rotenone treatment then became stable. *Gammarus* species (fresh water shrimp), a common fish food item, were detected in Devine Lake only when fish were present. Neighboring Ross Lake, in the Bob Marshall Wilderness, is fishless and was used to measure natural insect and plankton variation during the Devine Lake treatment and evaluation. *Gammarus* species were never detected in Ross Lake, although it is fishless. Invertebrate numbers in Ross Lake were reported to be relatively stable, but the diversity of insects fluctuated considerably over time.

The effects of rotenone on non-target organisms have been studied extensively. Mammals in general are not susceptible because they neutralize rotenone by enzymatic action in their stomach and intestines (AFS 2002). Laboratory tests fed forms of rotenone to rats and dogs as part of their diet for periods of six months to two years (Marking 1988). Researchers observed effects such as diarrhea, decreased food consumption, and weight loss, and reported that despite unusually high treatment rates of rotenone in rats and dogs, it did not cause tumors or reproductive problems in mammals. CDFG (1994) studies of risk for terrestrial animals found that a 22 pound dog would have to drink 7,915 gallons of lake water within 24 hours, or eat 660,000 pounds of rotenone-killed fish, to receive a lethal dose. The State of Washington reported that a half pound mammal would need to consume 12.5 mg of pure rotenone to be receive a lethal dose (Bradbury 1986). Considering the only conceivable way an animal can consume the compound under field conditions is by drinking lake or stream water, a half pound animal would need to drink 33 gallons of water treated at 2 ppm. Brooks (1961) reported that this amount is more on the order of 49 gallons. Similar results determined that birds required levels of rotenone at least 1,000 to 10,000-times greater than is required for lethality in fish (Skaar 2001). Cutkomp (1943) reported that chickens, pheasants and members of lower orders of *Galliformes* were quite resistant to rotenone, and four day old chicks were more resistant than adults. Ware (2002) reports that swine are uniquely sensitive to rotenone and it is slightly toxic to wildfowl, but to kill Japanese quail required 4500 to 7000 times more than is used to kill fish. One study, in which rats were injected with rotenone for a period of weeks, reported finding lesions characteristic of Parkinson’s disease (Betarbet et al. 2000). However, the results have been challenged on the basis of methodology: (1) that the continuous intravenous injection method used leads to “continuously high levels of the compound in the blood,” and (2) second, that dimethyl sulfoxide (DMSO) was used to enhance tissue penetration (normal routes of exposure actually slow introduction of chemicals into the bloodstream). Finally, injecting rotenone into the body is not a normal way of assimilating the compound. Similar studies (Marking 1988) have found no Parkinson-like results. Extensive research has demonstrated that rotenone does not cause birth defects (HRI 1982), gene mutations (Van Geothem et al. 1981; BRL 1982) or cancer (Marking 1988). Spencer and Sing (1982) reported that rats fed diets laced with 10-1000 ppm rotenone over a 10 day period did not suffer any reproductive dysfunction. Rotenone was found to have no direct role in fetal development of rats fed excruciatingly high concentrations of rotenone. Typical concentrations of actual rotenone used in fishery management range from 0.025 to 0.50 ppm and are far below that administered during most toxicology studies.

Chandler and Marking (1982) found that clams and snails were between 50 and 150 times more tolerant than fish to Noxfish (5% rotenone formulation), and Southern Leopard frog tadpoles were between 3 and 10 times more tolerant than fish. Fish killing concentration used as a comparison in their study are reported in Marking and Bills (1976). Based on these comparisons, all of the above species would be at their maximum tolerance range when exposed to 5% rotenone formulation during trout removal projects. Grisak (2003) found that tailed frog tadpoles and tailed frog adults were not affected by concentrations of Prenfish (5% liquid rotenone formulation) up to 0.75 ppm, and 80% mortality was observed at 1 ppm.

MFWP has used liquid formulated rotenone in seven high altitude mountain lakes in the Flathead basin to remove populations of unwanted trout. Surveys conducted on each lake have been used to assess the likely impacts that exposure to rotenone has had on the amphibians in each lake. Five of these lakes: Devine, North Jewel, South Jewel, East Jewel and West Jewel, provide evidence of what to expect for long term re-colonization and population status of amphibians following the application of Prenfish and subsequent restocking with westslope cutthroat trout, while the remaining two lakes; Tom Tom and Whale provide information about the short-term recolonization of amphibians following a Prenfish treatment.

Devine Lake is a 1-acre lake located in the Bob Marshall Wilderness that was treated with Prenfish in 1994 to remove an illegally introduced population of brook trout. The pre-treatment surveys were weighted heavily toward aquatic insects and although amphibians were observed, they were not quantified (J. Fraley, MFWP, personal communication, 2001). Post treatment surveys using the same protocol sampled two unidentified tadpoles in 1995, three unidentified tadpoles in 1996, eight adult spotted frogs in 2001, and in 2002 a single adult spotted frog and over 50 spotted frog tadpoles were observed.

North Jewel, South Jewel, East Jewel and West Jewel lakes are located in the Jewel Basin Hiking Area in the South Fork Flathead drainage. The surface area of all lakes combined is 12.4 acres (range 0.5 to 5.2) and depth ranges from 4 to 25 feet. The lakes were treated with liquid formulated rotenone in 1986. No pre-treatment data were found on file that quantified or qualified the amphibians. In 2001, a survey was conducted along the shore of each of the 4 lakes and found 26 frogs of both the spotted and tailed variety with both adults and juveniles present. In 2002, 76 spotted frog adults, 103 juveniles, and over 110 tadpoles were observed along with a single tailed frog adult. Amphibians were present at each of the four lakes.

Whale Lake is located on the Flathead National Forest in the North Fork Flathead drainage, is 5 acres in size and has a maximum depth of 15 feet. The lake was treated with Prenfish in October 2000. A pre-treatment survey using a dip net along the shoreline of Whale Lake found one adult western toad and an adult spotted frog. A survey in July 2001, approximately 9 months after treatment found four long toed salamander tadpoles. A survey conducted in July 2002, approximately 21 months after the treatment, yielded 21 salamander tadpoles, many of which had not yet emerged from their gelatinous matrix. This survey was conducted on only ½ of the lake. In September 2002, another survey was conducted where 16 salamander juveniles and a single tailed frog adult were observed.

Tom-Tom Lake is located on the Flathead National Forest in the South Fork Flathead drainage. It is 10.5 surface acres and has a maximum depth of 33 feet. The lake was treated with Prenfish in October 2000. A pre-treatment survey using a dip net long the shoreline of Tom-Tom Lake in August 2000 found four adult spotted frogs and numerous tadpoles along the littoral zone of the lake. The lake was surveyed in September 2001, approximately 1 year after the treatment, and surveyors netted over 25 long-toed salamanders in both larval and adult stage, over 100 juvenile spotted frogs, and 2 adult tailed frogs. In 2002, 115 spotted frog juveniles, a single adult, 2 long toed salamander juveniles, approximately 40 eggs, and 5 tailed frog tadpoles were found.

Wheeler Creek is the outflow stream for Tom-Tom Lake. The stream was detoxified with potassium permanganate at the mouth of the lake during treatment. In July 2001, approximately 9 months after the Prenfish application on Tom-Tom Lake, Wheeler Creek was electrofished at four different sites for 3.18 hours of total electrofishing, and 6 adult tailed frogs and 32 tailed frog tadpoles with specimens displaying developmental stages that included no legs, 2 legs, and 4 legs were collected. Many other tailed frog tadpoles were not netted due to swift flows and their ability to make a quick escape. Although not quantified, numerous stoneflies, caddis flies and dragonflies were also observed.

These findings suggest that a Prenfish application in high altitude lakes in the Flathead basin has little effect on the lifecycle of the local amphibian fauna. The long-term re-colonization of amphibians in a lake treated with liquid formulated rotenone appears to be uninhibited as evidenced by the Jewel lakes and Devine Lake examples. Whale and Tom Tom lakes were treated in the fall of the year just before ice-up. Administering a Prenfish treatment in the fall is advantageous because colder water temperature is believed to cause amphibians to enter winter dormancy and may protect them from exposure to Prenfish. The lakes included in this observation generally ice up in late October and re-open in early June. By observing salamander tadpoles in Whale Lake as early as July suggests that adults either were not affected by the application, or they were able to re-colonize almost immediately in the spring to deposit eggs and effect reproduction. Bioassay information from Grisak (2003) found that tailed frog tadpoles are not affected by Prenfish at 0.75 ppm, but were affected at 1 ppm. This suggests that 1 ppm is near the tolerance limit for tailed frogs, and this concentration would not totally eliminate tailed frogs from a stream. As Prenfish degrades to concentrations less than 1 ppm, it is not toxic to tailed frogs at all.

These findings are supported by Brown and Ball (1943) who reported that during a May rotenone treatment in Michigan, tadpoles were "greatly affected", but within three months, tadpoles were "extremely numerous". Bradbury (1986) points out that the timing favors certain organisms. For example, although Chandler and Marking (1982) reported that frog tadpoles were 3 to 10 times more tolerant than fish to rotenone, the fact that many amphibians have metamorphosed by fall may safeguard them from rotenone treatments because they are not gill breathers by this time. Applications of rotenone during the fall ensure a higher survival of non-target amphibians. Bradbury (1986) points out that although it is likely that some amphibians may be affected during a rotenone treatment, this is balanced by the fact that larval amphibians are tolerant to rotenone formulations at trout killing concentrations. Based on this information, the resiliency of amphibians to rotenone, and the fact that rotenone treatments in the fall of the year ensure that nearly all are in their winter dormancy, no amphibian impacts are expected. The bioassays conducted by Grisak (2003) suggested that tolerance limits of tailed frogs to Prenfish was near 1 ppm which is the target concentration for lake treatments in the Flathead basin.

Several hazard assessments for human health have also been conducted. The lowest level estimated for toxicity would require a 150 pound person to drink, at one time, 47,500 gallons of water containing 100µg/L rotenone to receive a lethal dose (Gleason et al., 1969), or eat 400 pounds of rotenone-killed fish at one sitting. (for reference; the rotenone concentration of Prenfish used in this project would be 0.05 mg/L). Acute oral toxicity for humans would require a 150 pound person to eat between 5 and 71 ounces of pure formulation in order to die (Bradbury 1986). Keith (1967) reported that following the application of 5,700 pounds of 7.5% rotenone in Blue Mountain Lake, Arkansas, an estimated 5-10 thousand people came to dip out the edible species of fish, presumably for consumption. In their description of how South American Indians prepare and apply *Timbó*, Teixeira et al. (1984) reported that the Indians extensively handled the plants during a mastication process, and then swam in lagoons with the plant pulp on their backs for distribution. No harmful effects were reported.

Finlayson et al. (2000) reported that the EPA "has concluded that the use of rotenone for fish control does not present a risk of unreasonable adverse effects to humans and the environment" . In relation to air quality, he further notes that "No public health effects from rotenone use as a piscicide have been reported." No waiting period is specified for swimming in rotenone-treated water.

Skaar (2001) notes that the National Academy of Sciences established in 1983 a Suggested-No-Adverse-Response-Level of rotenone in drinking water of 14 ug/L, assuming that a 70-kg person drinks 2 liters of water per day for a lifetime. In 1997, the U.S. EPA established a "reference dose" of 0.004 mg/kg/d, based on a No-Observable-Adverse-Effect-Level in rats of 0.38 mg/kg/d. Skaar (2001) notes that freshly treated lakes would have a rotenone level much higher (100 ug/L); however, he notes that since the rotenone would "probably dissipate totally within a month or two, it doesn't seem possible for chronic effects to ever develop from drinking from a rotenone-treated lake".

No contamination of groundwater is anticipated to result from this project. Rotenone binds readily to sediments, and is broken down by soil and in water (Skaar 2001; Engstrom-Heg 1971, 1976; Ware 2002). Rotenone moves only 1 inch in most soil types; the only exception would be sandy soils where movement is about 3 inches (Hisata 2002). In California, studies where wells were placed in aquifers adjacent to and downstream of rotenone applications have never detected rotenone, rotenolone, or any of the other organic compounds in the formulated products (CDFG 1994). Case studies in Montana have concluded that rotenone movement through groundwater does not occur. At Tetrault Lake, Montana rotenone was not detected in a nearby domestic well, which was sampled 2 and 4 weeks after applying 90 ppb rotenone to the lake. This well was chosen because it was down gradient from the lake and also drew water from the same aquifer that fed and drained the lake. In 1998, a Kalispell area pond was treated with Prenfish. Water from a well, located 65 feet from the pond, was analyzed and no sign of rotenone was detected. In 2001, another Kalispell area pond was treated with Prenfish. Water from a well located 200 feet from that pond was tested 4 times over a 21 day period and showed no sign of contamination.

Bradbury (1986) reported that studies show water temperature, dissolved oxygen, pH, alkalinity, and carbon dioxide are not affected by water treatment with rotenone. Minor temporary changes in taste and odor can be detected. No well-designed studies have ever shown detectable levels of any of the chemicals involved, post-treatment (Skaar 2001).

The "inert" ingredients commonly associated with formulations of rotenone are highly volatile and water soluble (Skaar 2001). Skaar notes that "These constituents tend to dissipate to non-detectable levels in less than 14 days in treated impoundments with water temperatures above 50°…. none of the constituents have been found in groundwater aquifers following treatment" . TCE, a known carcinogen, "dissipates quickly by volatilization, less so by oxidation, and very slowly by hydrolysis". Results from CDFG (1994) show that although it can be found in impoundments three weeks after treatment; the study notes that in Lake Davis, California, TCE concentrations fell below detection limits after 37 days post-treatment. Piperonyl butoxide (the other active ingredient in synergized formulations) remained above the detection limit of 2 ppb in Lake Davis from treatment (October 15) to the following June.

Because dead fish would result from a Prenfish treatment, there would be a temporary abundance of fish available for predators afterwards; this would be followed by a temporary reduction in food supplies until the fish are restored. The AFS Rotenone Manual notes "There is no indication that this temporary reduction results in any significant impacts to most bird or mammal populations because most animals can utilize other water bodies and sources for food" (Finlayson et al. 2000).

As a fisheries management tool, rotenone has been used successfully for both complete and partial removal of fish (Keith 1967). Klein (1960) reported that rotenone was used to completely remove brook trout from Officers Gulch Lake and Horseshoe Lake, Colorado. The lakes were subsequently restocked with native cutthroat trout. One of the most notorious examples of rotenone achieving 100% success in a large scale operation was that of the Diamond Lake treatment in Oregon in 1954 which was hailed as the largest fish eradication project ever attempted in modern fishery management (ODFW 2002; Dimick 1954). Diamond Lake is 2,982 surface acres, has a maximum depth of 53 feet and contained 53,000 acre feet of water at the time of treatment. One hundred tons of powdered rotenone were added to the lake and completely removed an illegally introduced population of Klamath Lake roach chub, estimated at 32,000,000 fish. A partial removal of stunted rock bass from Standard Lake, Michigan was reported by Beckman (1940) who concluded that the treatment was effective in achieving the desired outcome of reducing an overpopulated lake and ultimately improved angling quality.

MFWP has conducted 74 applications using both powdered and liquid formulation rotenone on 63 lakes in the Flathead basin from 1948 through 2001. Seven of these lakes (11%) have required multiple treatments. Reasons for multiple treatments include: the survival of fish in untreated areas (springs, etc.); the inability to completely remove the source of unwanted fish; or illegal introduction following a treatment. The target species from these seven lakes have been pumpkinseed sunfish, northern pikeminnow, black bullhead, red-side shiner, yellow perch, largemouth bass, coarse scale sucker, longnose sucker, finescale sucker, peamouth, eastern brook trout, and rainbow trout. The average length of time between repeat treatments has been 19 years; and ranges from 8 to 36 years. The number of lakes treated with rotenone in the Flathead basin represents 12% of the 505 lakes that MFWP considers as managed fisheries in this area. Rotenone has been used successfully to remove trout from lakes that occur in the project area. In 1986, the East, West, North, and South Jewel lakes were treated with liquid formulated rotenone to remove populations of rainbow trout. In 1994, Devine Lake (located in the Bob Marshall Wilderness) was treated with Prenfish to remove the only known population of brook trout from the South Fork Flathead drainage. In 2000, Tom Tom Lake was treated with Prenfish to remove hybrid trout. All six lakes were restocked with genetically pure westslope cutthroat trout.

The lakes that would be treated with Prenfish would be without a fishery for up to 2 years following the treatment. Klein (1960) reported that fishing was impaired for two years in two high mountain lakes in

Colorado following a rotenone treatment. Restocking of most of the lakes would occur the following July and continue for two more years until a population has been established. Some lakes would be restocked with multiple sizes of fish in an effort to restore the fishery as quickly as possible. Fish of catchable size would not be available to anglers until the second year after the treatment. Tom-Tom Lake was treated with Prenfish in 2000, the lake was stocked with multiple sizes of fish 9 months after the treatment, and by 2002 anglers were catching 10-12 inch fish.

Prior to the application of Prenfish each lake would be thoroughly surveyed to identify volume, identify number and location of water inflows and outflows, estimate or measure their flow rates, measure water chemistry and temperature, collect plankton samples, and conduct an amphibian survey (Maxell 2002). Lake volume is calculated through a series of depth measurements and GPS (global positioning system) locations while in a raft on the lake. A depth measurement is recorded at each GPS location. These data are subsequently superimposed on an image of the lake surface to correct for boundary errors, and then entered into a computer program called TIN (triangulated integrated network), which uses the GPS and depth data to create volumetric layers within the lake surface image. The program constructs a three-dimensional lake basin as a map. From this three-D image, the program calculates the lake volume. Using this volumetric information, MFWP personnel can calculate the proper amount of Prenfish needed to eliminate fish from the lake. Proper volume calculations ensure that the Prenfish is applied at a concentration sufficient to kill fish. All calculations are double-checked for accuracy.

The stream system that flows out of the lake is surveyed to determine volume and flow rate using standard US Geological Survey methods. From this, important factors for dilution and detoxification can be made. Also, experiments using potassium permanganate would be implemented to determine the organic demand of a stream to ensure proper detoxification of Prenfish if necessary.

Application during the fall takes advantage of three environmental factors that are advantageous. First, limnetic turn-over occurs in September/October which thoroughly mixes lake water and causes density and temperature to be consistent throughout the lake. Clemens and Martin (1953) reported that rotenone was applied in 27 ponds in Oklahoma that were thermally stratified. Because of the temperature and density barriers, the rotenone in these ponds did not completely penetrate to the bottom. To avoid penetration problems, Prenfish would be applied after limnetic turnover occurs. Limnological data collected throughout the Flathead basin indicate that lakes turnover when water temperatures reach 46^{o}F (Scott Rumsey, MFWP, personal communication, 2002). Thermal data collected from Black Lake in 2002 indicate the lake experienced limnetic turnover on October 1 when the water temperature reached 47^{o}F throughout (Figure 5). Wildcat Lake experienced limnetic turnover on October 4 when the water temperature reached 46^{o}F throughout (Figure 6). This allows Prenfish to mix thoroughly. The deepest lake MFWP has successfully treated with rotenone was Lion Lake, in the South Fork Flathead drainage. The lake is 112 feet deep and was treated in 1993 to remove pumpkinseed sunfish and yellow perch. Second, application during the fall makes advantage of low or no inflow and outflow at many of the lakes, which makes application and containment easier. Finally, because high altitude lakes usually ice-up in October, many non-target organisms like amphibians, bears and nesting birds are not present at the sites.

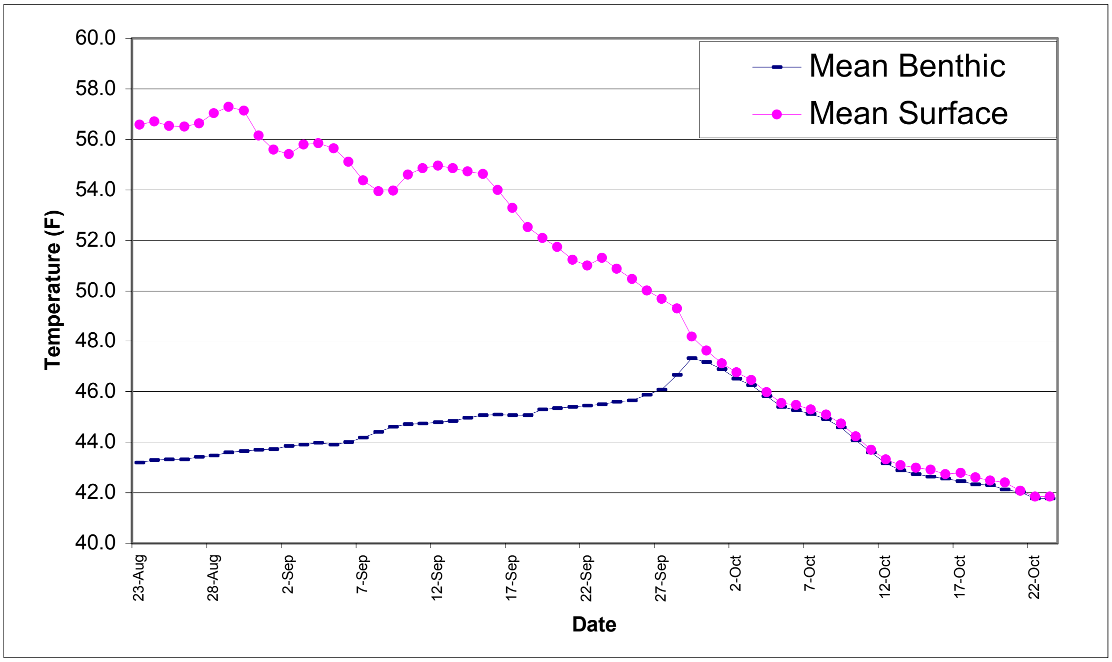

Figure 5. Inflection point of mean daily surface and benthic temperatures (^{o}F) of Black Lake, South Fork Flathead River drainage, 2002.

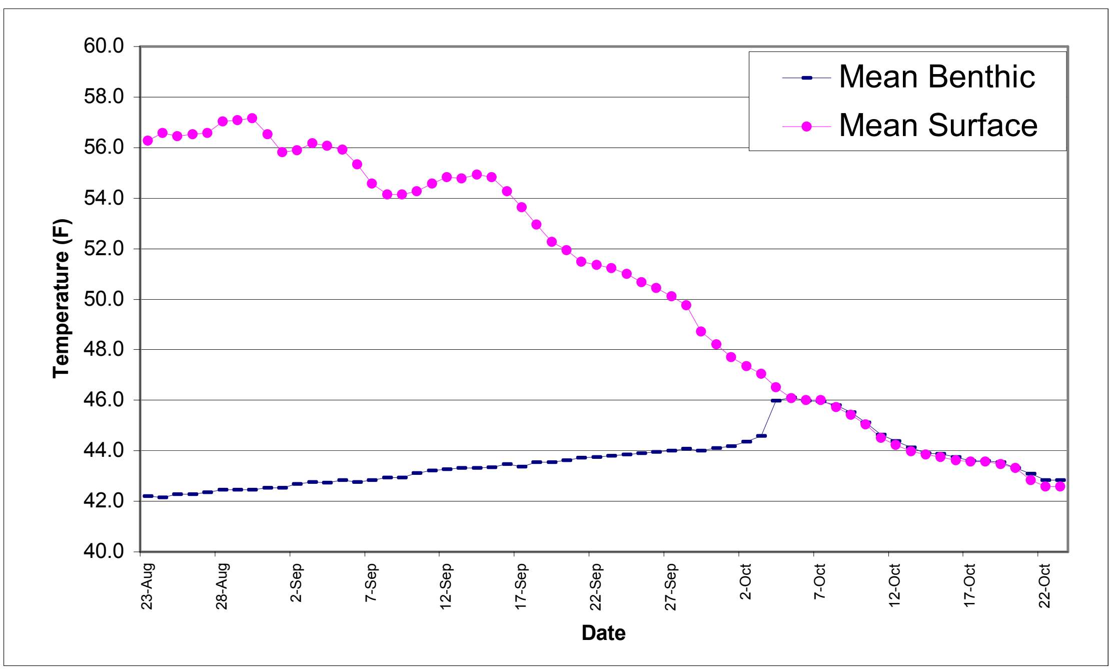

Figure 6. Inflection point of mean daily surface and benthic temperatures (^{o}F) of Wildcat Lake, South Fork Flathead River drainage, 2002.

Rotenone is manufactured and shipped in both powdered and liquid form, and each requires different application methods. The powdered formulation of rotenone is occasionally used in Montana. Application of the powdered form first requires it to be mixed with water on site using an electric cement mixer, which creates a slurry solution. During the mixing and application process, all personnel must were protective clothing, eye protection and respirators to avoid making contact with the compound. Once mixed, it may be applied in two ways. Most commonly, the slurry is carried by a boat and siphoned out of a bucket by a venturi suction mechanism mounted to the lower unit of an outboard motor, directly in front of the propeller. The propeller mixes the rotenone with lake water and facilitates distribution. In deep lakes, a weighted hose of appropriate length may be used to distribute in deeper waters, or it can be pumped down to the prescribed depth. The second method is typically used in small shallow lakes (<15 feet deep). An auxiliary pump is used to mix lake water with rotenone, and then the mixture is sprayed over the lake surface using a high pressure fire hose. The rotenone and applicator are transported around the lake in a boat.

Because fish can smell and taste rotenone in water they will attempt to avoid it. Often it is necessary to treat freshwater inputs to a lake during an application to prevent fish from seeking out fresh-water and avoiding the treatment. There are three methods of accomplishing this. First, a small amount of powdered rotenone may be placed in a burlap sack, then in a stream and allowed to leach out slowly until it is gone. Second, crewmembers often walk the lake perimeters to see whether fish are seeking fresh-water inputs that were not previously identified (i.e., spring inputs versus surface water). A backpack sprayer may be used to spot-spray these water sources. Because the application of rotenone causes lake water to temporarily turn milky-white, observing the clear plumes of fresh water among the treated water may identify them. Finally, a drip station may be installed to administer a known concentration of Prenfish at surface water inputs. MFWP uses 7-gallon poultry waterers as drip stations to dispense Prenfish at a prescribed rate through a hole in the bottom.

Before treatment begins, the project supervisor would formulate a treatment plan and review it with all personnel. After water inflows and outflows are identified the appropriate method for treating them is selected and implemented. If it were necessary to monitor the toxicity of water leaving a lake, live caged fish would be placed at predetermined locations downstream. The boat crew would then dispense the Prenfish around the shoreline of the lake, continuing the application in concentric rings toward the center until the upper stratum was treated. If necessary, the boat would use a weighted garden hose, or a pump to deliver Prenfish to deeper water. During the lake treatment, all known freshwater inflows would be treated to prevent fish from avoiding the rotenone. After the rotenone was administered, it would be allowed to set for about 12 hours.

The day following the treatment, dead fish would be removed from the shoreline, and then taken to deeper water and sunk. Dead fish would be removed from as much of the stream systems as reasonably possible and disposed of. This would prevent them from becoming an attractant to bears and birds, improves aesthetics of the site, and would provide nutrients back to the lake to stimulate plankton and insect production. Bradbury (1986) reported that approximately 70% of rotenone fish killed in Washington lakes never surface. Although no trout were involved with his study, Parker (1970) reported that at water temperatures of 40°F and less, dead fish required 20-41 days to surface. The most important factors inhibiting fish from ever surfacing are cooler water (<50°F) and deep water (>15 feet). Nearly all of the lakes listed in this proposal meet those criteria and they usually have ice formation by the end of October. Bradbury (1986) reported that 9 of 11 water bodies in Washington treated with rotenone experienced an algae bloom shortly after treatment. This is attributed to the input of phosphorus to the water as a result of decaying fish. Bradbury further notes that approximately 70% of the phosphorus content of the fish stock will be released into the lake through bacterial decay. This action stimulates phytoplankton production, then zooplankton production, and starts the lake toward production of food for fish.

A typical application using powdered formulation on a small lake would require a minimum of two personnel to mix the slurry, one to organize materials and load the boat, and one for distributing by boat. Additional personnel are required if freshwater sources are present and require spraying or drip stations, and if detoxification and caged fish monitoring is required. The number of people needed would increase with the size and complexity of an individual lake treatment.

Because powdered rotenone requires more time to mix and supplemental equipment like complete body protection, cement mixers and generators, and all the lakes where rotenone is considered are located in remote and confined areas, it has not been developed as a preferred method.

Liquid formulation rotenone is applied to a lake in the same manner as the powdered form, but does not require the additional time and equipment necessary for on site mixing, respirators or full body protection.

In accordance with MFWP policy, all rotenone applications must be conducted according with department guidelines (MFWP 2001a). In addition, MFWP must apply for and secure a 308 permit from MDEQ. This permit allows for short-term exemptions of Montana's surface water quality standards. At least one applicator licensed by the Montana Department of Agriculture must be on site to supervise or administer the project. Non-licensed applicators may assist with the project, under the direct technical supervision of the licensed applicator. The project supervisor must be well versed in the state regulatory requirements regarding safe and legal use of the rotenone product and applicator safety. All personnel involved with the rotenone application must receive safety training specific to the formulated rotenone product that would be used. At a minimum, specific safety training must include information on the following: (1) properly reading and understanding the product label; (2) the acute and chronic applicator exposure hazards; (3) routes and symptoms of pesticide overexposure; (4) how to obtain emergency medical care; (5) decontamination procedures; (6) how to use the required safety equipment; (7) safety requirements and proper procedures for pesticide handling, transportation, storage and disposal. The Training Records must be maintained in accordance with federal and state regulatory requirements.

When applying liquid rotenone personnel are required to wear protective clothing, including chest waders, waterproof jacket (rain jacket), and rubber gloves. If mixing powdered rotenone, personnel are required to wear respiration filter masks and eye protection to keep from inhaling or ingesting any powdered material. Pumping any rotenone mixture for a surface application requires that personnel wear respiration filter masks and eye protection to avoid inhaling or ingesting aerosol droplets.

Some temporary recreational and aesthetic impacts may be expected in a body of water where dead fish appear in some quantities. Removing the fish from the shoreline following the procedure would mitigate this. A treated body of water would provide no angling opportunities until after it is restocked. Anglers would need to use other nearby water resources until a fishery was re-established.

Use of rotenone has raised controversy in some places, particularly where sufficient public involvement or education has not taken place. According to members of the AFS Fish Management Chemicals Subcommittee Task Force on Fishery Chemicals, controversy springs from three main sources: "(1) persons who oppose changes to a perceived natural situation or oppose the use and development of fish monocultures, (2) persons who are alarmed by the perception of widespread application of chemicals that might be dangerous to people and the environment, and (3) persons who oppose the killing of fish by any means (Finlayson et al 2000).

California, Washington, and Michigan, among other states, have prepared programmatic environmental studies of rotenone use in fisheries management (CDFG 1994; Hisata 2002; MDNR 1990). Site-specific environmental studies are conducted for each individual rotenone treatment in California (CDFG 1994).

The State of Montana has Human Health water standards and the EPA has water quality criteria for chronic effects of some of these compounds. The EPA has no drinking water standards for rotenone. The use of rotenone in Montana has been governed for many years by the "General Prohibition" rules (ARM 17.30.637 (8)), which states:

> *"Application of pesticides in or adjacent to state surface waters must be in compliance with the labeled direction, and in accordance with provisions of the Montana Pesticides Act (Title 80, Chapter 8, MCA) and the Federal Environmental Pesticides Control Act (7 USC 136, et seq., (Supp. 1973) as amended). Excess pesticides and pesticide containers must not be disposed of in a manner or in a location where they are likely to pollute surface waters."*

This exemption from water quality standards was officially adopted into statute in 1993, with the passage of section 75-5-308 of the Montana Water Quality Act, now amended, which is entitled "Short-term water authorizations—water quality standards." This statute states:

> *"(1) Because these activities promote the public interest, the department [DEQ] may, if necessary, authorize short-term exemptions from the water quality standards for the following activities: (a) emergency remediation activities that have been approved, authorized, or required by the department; and (b) application of a pesticide that is registered by the United States environmental protection agency pursuant to 7 U.S.C. 136(a) when it is used to control nuisance aquatic organisms or to eliminate undesirable and nonnative aquatic species.*
>
> *(2) An authorization must include conditions that minimize, to the extent practicable, the magnitude of change in the concentration of the parameters affected by the activity and the length of time during which any change may occur. The authorization must also include conditions that prevent significant risk to public health and that ensure that existing and designated uses of state waters are protected and maintained upon completion of the activity. Authorizations issued under this section may include conditions that require water quality or quantity monitoring and reporting. In the performance of its responsibilities under this section, the department may negotiate operating agreements with other departments of state government that are intended to minimize duplication in review of activities eligible for authorization under this section."*
>
> *(3) An authorization to use a pesticide does not relieve a person from the duty to comply with Title 80, chapters 8 and 15. The department may not authorize an exemption from water quality standards for an activity that requires a discharge permit under rules adopted by the board pursuant to 75-5-401."*

Another statute which applies to MFWP use of pesticides include 75-5-317 "Nonsignificant activities." The passages relevant to MWFP activities are:

> *(1) The categories or classes of activities identified in subsection (2) cause changes in water quality that are nonsignificant because oftheir low potential for harm to human health or the environment and their conformance with the guidance found in 75-5-301 (5)(c).*
>
> *(2) The following categories or classes of activities are not subject to the provisions of 75-5-303: (g) short-term changes in existing water quality resulting from activities authorized by the department pursuant to 75-5-308.*

These procedures have been followed in the 1990s. In addition, the State has prepared Environmental Assessments and issued public notices for each project that involves the use of rotenone on public lands.

For each water treated, the certified applicator submits a Montana Department of Agriculture - Record of Application Report that describes, among other things, the type and amount of pesticide applied, the area treated, application rate, equipment used, possibility of a complete kill, water conditions at the time of treatment, and detoxification measures, if any.

<u>Potassium Permanganate</u>

Potassium permanganate is a strong oxidizer that breaks down into potassium, manganese and water (Finlayson et al. 2000). This compound is used in fish aquaculture to remove fungus and parasites, and to increase soluble oxygen in water thus averting fish kills (Lay 1971). It can be used to detoxify both antimycin (Marking and Bills 1975) and rotenone (Engstrom-Heg 1976, Engstrom-Heg 1972, Lay 1971). Although it is used in fish aquaculture to benefit fish, and it is used to neutralize fish toxin, it also can be toxic to fish.

Marking and Bills (1975) reported that it is most toxic in low water temperatures, in hard water, and in high pH. Recent bioassays conducted by MFWP indicate that when applied at 1.5 ppm and greater, and with no other substances to oxidize with, it can achieve 100% mortality in westslope cutthroat trout after 16 to 24 hours of exposure (Grisak et al. 2002). Fish exposed to concentrations less than 1.5 ppm survived. Grisak (2003) found that tailed frog tadpoles and tailed frog adults exposed to 3 and 4 ppm caused 13% death at 16 and 24 hours exposure, respectively. No greater mortalities were observed after the 16-hour observation at 3 ppm.

Readily oxidizable substances rapidly decrease the activity of potassium permanganate (Marking and Bills 1975). These substances might include algae on a stream bottom, gravel, mud, leaves from trees, soil, etc. Engstrom-Heg (1976, 1971) reported the necessity and methodology for measuring the amount of oxidation that a particular stream bottom and stream water would have (the "demand") on potassium permanganate. Using a colorimeter instrument and a small amount of potassium permanganate, the demand of a particular stream can be measured prior to treatment so applicators can compensate for this demand and ensure the appropriate concentration is available to interact with rotenone or antimycin. Furthermore, these assays provide applicators with the amount of contact time needed for potassium permanganate to react with antimycin or rotenone to ensure proper detoxification in a stream (Engstrom-Heg 1972). Finlayson et al. (2000) provide an example of an application in Utah where 3.95 ppm potassium permanganate were required to detoxify 2 ppm rotenone in 60 minutes. The organic demand of this stream on potassium permanganate was 3 ppm, and the remaining 0.95 ppm potassium permanganate was left to detoxify the rotenone. Engstrom-Heg (1972) reported that a New York stream with a demand of 1.6 ppm, required 4.6 ppm potassium permanganate to detoxify 1 ppm rotenone in 14 minutes. A rule of thumb was proposed that 20 minutes of contact time was necessary for potassium permanganate to successfully neutralize rotenone. Some variance can be expected for stream flow rate and water temperature. Lawrence (1956) reported that potassium permanganate could neutralize rotenone over a water temperature range of 44^{o} to 81^{o} F.

Applicators must be aware of the amount of time necessary for potassium permanganate and the oxidizing compound (rotenone or antimycin) to contact each other to facilitate detoxification. This time can range from 30 to 60 minutes depending on how fast the stream is flowing. Stream flow can be measured with a flow meter so applicators can calculate the distance a stream would flow over time. Potassium permanganate can detoxify these two compounds quicker if higher concentrations are used.

Potassium permanganate was used to detoxify antimycin during the treatments of Pear Reservoir and Lower Hutchinson Lake, Colorado (Rosenlund and Stevens 1992). Moore et al. (2001) reported that it was used to detoxify antimycin during the treatment of Sam's Creek, Tennessee. Stefferud et al. (1992) reported potassium permanganate was used to detoxify antimycin during the treatment of White Creek, New Mexico. Lawrence (1956) reported that it was used to detoxify rotenone in Uchee Creek, Alabama. Engstrom-Heg (1976) reported that rotenone treated water from the outflow of Lebanon Reservoir in New York was successfully detoxified with potassium permanganate.

Potassium permanganate is shipped by the manufacturer in dry crystalline form in 5-gallon containers. In dry form it weighs 11 pounds per gallon. Lay (1971) reports that it is odorless, non-corrosive, does not produce harmful vapors, and is dustless, safe to handle, and can be stored indefinitely. As a fish toxin neutralizer, it is mixed with water on site and administered using a 7-gallon poultry waterer with a small hole drilled in the bottom to administer the appropriate concentration. When mixed with water it becomes brilliant purple in color. This color dissipates rapidly with detoxification. Because it is a water based solution, and most treatments occur in the fall, detoxification stations are susceptible to freezing. In 2002, MFWP tested potassium permanganate drip stations in below freezing weather and found that insulated heated boxes covering the drip stations prevented freezing for periods of up to 10 hours. This would ensure proper detoxification in freezing weather.

A typical monitoring/detoxification station would consist of an attendant who monitors the stream water with a cage of live fish. Depending on the location of the station, live fish may be brought from a hatchery (genetically pure westslope cutthroat, in case of escapement) or electrofished on site. A monitor would mix a small amount of potassium permanganate and administer it upstream. Once in the stream, it would be measured using a colorimeter. At a known distance point downstream the concentration would be measured again using a colorimeter. The difference between the upstream measurement and downstream measurement indicates the amount of potassium permanganate being oxidized by the stream. Taking this into account, the applicator would calculate the proper concentration needed to oxidize the antimycin or rotenone in the stream. The attendant would stay at the site and monitor the condition of the fish. If they appear distressed or are dying, the detoxification process would be implemented and continue for 48 hours. Two-way radio and/or messenger would maintain communication with applicators at the lake.

Because it is a strong oxidant, the compound is used widely in the treatment of municipal water treatment processes. The following information on potassium permanganate was obtained from the Carus Chemical Company. The product line for potassium permanganate marketed by Carus is CAIROX®.

Potassium permanganate is one of the most widely used inorganic chemicals for the treatment of municipal drinking water and wastewater. Hundreds of drinking water treatment plants use this versatile oxidant to improve taste & odors; to oxidize iron, manganese and arsenic; to treat for and control zebra mussels and biofilm in raw water intake lines; to remove color; and as an alternative pre-oxidant to chlorine in a trihalomethane (THM) control program. Potassium permanganate is used to treat ground water as well as surface water supplies.

In municipal wastewater systems, potassium permanganate is used cost effectively to control odors in collection systems, in the treatment process, and in the mechanical dewatering operations. It is especially effective in oxidizing sulfides and mercaptans, the worst odors generated during the collection and treatment of municipal wastewater.

In the American Waterworks Association's (AWWA) Water Industry Data Base (WIDB), potassium permanganate is listed as the second most widely used chemical for predisinfection and oxidation by treatment plants processing surface water. According to the data base, over 32.9% of the surface water plants use potassium permanganate, second only to chlorine for disinfection and oxidation. In groundwater plants over 22.6% of the plants practicing iron and manganese removal are using potassium permanganate.

The AWWA Research Foundation conducted a survey of treatment plants and their practices for controlling tastes and odors. Next to activated carbon, potassium permanganate was the most widely used taste and odor control process. Over 48% of the plants in the survey listed permanganate usage, with an 86% satisfaction factor.

Applications

Potassium Permanganate is being used successfully by utilities to remove iron, manganese, and hydrogen sulfide from both groundwater and surface water. In groundwater applications, the permanganate is normally applied directly ahead of greensand filtration. In surface water treatment plants, permanganate is applied as far ahead of the rapid mix as plant design allows, preferably at the raw water intake. Factors that affect oxidation and coagulation include pH, hardness, alkalinity, TOC, and time between permanganate addition and the addition of coagulants. It is being used by surface water utilities to successfully remove the cucumber, fishy, septic, and other odors caused by blue-green algae. In combination with activated carbon, utilities report that permanganate is cost effective in controlling musty, earthy odors. The oxidant should be applied before the rapid mix, ahead of activated carbon. It has been approved by U.S. EPA as an alternative oxidant to chlorine in a THM control program. Arsenic (+3) is readily oxidized to Arsenic (+5) by permanganate. The oxidized arsenic is easily adsorbed by alum, iron salts, or manganese treated greensand. Utilities report that potassium permanganate applied at the raw water intake successfully removes zebra mussel infestations as well as preventing the veligers from settling in the pipeline. Other pipeline biofilms are also controlled. The major application of potassium permanganate in municipal drinking water plants using surface water, is for the control of compounds causing taste and odors. Surveys have shown that most off-flavors in drinking water are caused by metabolizing blue-green algae. Potassium permanganate treatment either alone or in combination with other treatment technologies is effective in controlling these algae generated odors.

Potassium permanganate is more effective for "cucumber" and "grassy" odors than either chlorine or chlorine dioxide, according to the work presented at the Water Quality Technology Conference (WQTC).

Potassium permanganate can be combined with powdered activated carbon (PAC) to achieve odor control of musty and earthy odors caused by MIB and Geosmin. Recycled decant and backwash water can cause taste and odor problems. Permanganate treatment was proven to more economical and effective than ozone for the control of these taste and odors. Trihalomethanes (THMs) and other chlorinated organics are formed when "free" chlorine or other halogens react with organic precursor chemicals in the raw water. By delaying the application of chlorine and applying potassium permanganate to the raw water as a substitute oxidant, and practicing good coagulation, the levels of THMs and other chloro-derivatives can be reduced to meet the standards of the Safe Drinking Water Act (SDWA). Potassium permanganate is listed by U.S. EPA in the Federal Register as one of the technologies that can be used in a THM control program.

Manganese, along with iron can be a problem in both surface water and groundwater plants. Potassium permanganate effectively oxidizes both of these metals quickly and efficiently. In groundwater plants, permanganate is normally combined with manganese treated greensand filtration.

Arsenic standards may be reduced by changes in the SDWA. Potassium permanganate has been proven an effective oxidant to convert arsenic so that it can be adsorbed in subsequent treatment unit processes.

Zebra mussel control is essential in many surface water treatment plants. Potassium permanganate has case history articles available from utilities who claim effective control using potassium permanganate.

Since its introduction in the early 1980s, the use of potassium permanganate for wastewater treatment has grown to become one of the largest U.S. applications of this versatile oxidant. The major use is for the oxidation of hydrogen sulfide, the "rotten egg" odor caused by the reduction of sulfur compounds normally present in wastewater. In test after test, it has been proven to be the fastest working oxidant for this application. Most other sewage odors can also be controlled using potassium permanganate. It's application is especially effective in mechanical biosolids dewatering where toxic sulfides pose a threat to the health of wastewater plant operators as well as to the environment. Control of sulfides also reduces corrosion. Case histories and technical support literature are available.

Potassium permanganate rapidly oxidizes sulfides and other sewage odors in collection systems, in plant treatment processes, and in mechanical biosolids dewatering operations. Corrosion control, improved plant performance and polymer savings are some of the benefits achieved. Addition of permanganate to the Return Activated Sludge resulted in the reduction of odors from the aeration tanks of a conventional activated sludge wastewater treatment plant without any change occurring to the microbiology of the system.

Hydrogen sulfide is one of the deadly gases that can be formed in the collection and treatment of municipal wastewater. Other organic sulfur compounds include thiols, mercaptans, and disulfides. These compounds and other nitrogen containing compounds can produce odors described as "skunk, rotten cabbage, rotten eggs, fishy, ammonia, and decaying flesh." The lack of oxygen in the collection system force mains and the active anaerobic bacteria present in the sewage system can chemically reduce sulfates and other chemicals present to produce these odorous compounds. These odors become prevalent in lift stations, force main discharges, and at the headworks of the treatment plant. Potassium permanganate can be applied to the collection system ahead of the odor source to control most of these odors.

In-plant odors can occur at the headworks, in the primary and secondary clarifiers, in the activated sludge basins, in the fixed film reactors, and during bisolids handling and disposal. Potassium permanganate can be applied economically and effectively to oxidize the odorous compounds, not just mask or cover them up. Potassium permanganate is normally introduced early in the drinking water treatment process to allow for as much reaction time as possible before other treatment chemicals are added. This allows for the permanganate to be reduced to form maganese dioxide, which is then coagulated and flocculated out of the system. Only systems employing filtration should use potassium permanganate because of the need to remove the by-product manganese dioxide from the water. Industries have developed analytical methods to measure residual permanganate in water to provide analytical control tools. Potassium permanganate can be measured in the presence of residual by-product MnO_2 and chlorine.

In wastewater treatment systems, potassium permanganate should be applied as close to the odor source as possible to provide the best and fastest control. In dewatering operations, the potassium permanganate is applied directly ahead of the sludge pumps or into the sludge conditioning tanks.

Summary and conclusions

After completing the analysis of fish removal methods, the following information was summarized for each method (Table 4):

Table 4. Summary of fish removal methods evaluated for South Fork Flathead westslope cutthroat trout conservation program.

Method	Advantages	Disadvantages
Downstream barriers	-no risk to plankton, insects, amphibians -maintain angling -may be socially acceptable over other methods	-requires construction in remote area -permanent or near permanent presence (concrete, gabion) -open to vandalism -high maintenance -dependant on appropriate water levels (too high, too low) -not proven to contain fish -does not work in winter because of ice -does not remove compromising genetic material -won't block fry -does not meet project goals
Gill netting	-no risk to plankton, insects, amphibians -may be socially acceptable over other methods -proven technique on small shallow lakes	-requires several years to implement -not successful on large or deep lakes (>5 acres, > 30 ft deep) -selective for larger sized fish -fish may avoid net -requires high man hours -fishery is impaired for several years -requires motor boat to set and pull -may ensnare non-target fish-eating birds -does not work in streams -does not meet project goals
Explosives	-may be socially acceptable over other methods -can be packed by livestock to remote areas -removes high number of fish in short time	-may trigger landslides, avalanches, destabilize lake bed -estimated to kill only 85%-95% of fish -not a proven technique (especially in streams) -will likely kill most of all non-target creatures in a lake -does not meet project goals

Table 4 (cont'd)

Genetic swamping	-no risk to non-target organisms -may be socially acceptable over other methods -maintain angling -demonstrated to improve genetic composition in some lakes and streams in the project area	-may require 20-40 years to be successful -high densities of fish may reduce size, weight and fitness of populations, may affect ability to reproduce -dependant on spawning habitat in each lake and stream to facilitate progressive hybridization -allows time for hybrid trout to influence remaining or other pure populations -high densities may promote outmigration leading to downstream introgression -species may separate spatially or temporally affecting success -does not meet project goals
Seining	-no risk to plankton, insects, amphibians -may be socially acceptable over other methods	-not a proven technique at removing all fish -requires many years to implement -requires use of boat for extended period of time -dependant on suitable shoreline for entrapment -may be flawed by snags (rocks, trees, etc) -fishery is impaired for several years -does not work in high gradient streams -does not meet project goals
Trap netting	-no risk to plankton, insects, amphibians -may be socially acceptable over other methods	-not proven technique at removing all fish -depends heavily on fish behavior -requires a motor boat to set and check -requires extended period of time to implement -fishery is impaired for extended period of time -requires high man hours -does not work in high gradient streams -does not meet project goals
Electrofishing	-little risk to plankton, insects, amphibians -may be socially acceptable over other methods -works well in streams	-not a proven technique at removing all fish in lakes -requires high man hours -requires extended period of time to implement -requires large boat in remote area -requires using motor boat and generator in wilderness for extended period of time -low conductivity in project lakes decreases efficiency -high escapement ability in clear deep waters -requires operation at night -does not meet project goals

Table 4(cont'd)

Tiger muskellunge	-little risk to plankton and insects -sterile, will not reproduce, easy to control -top level predator, efficient -may provide limited fishery -may be socially acceptable over other methods	-requires extended period of time to implement -trout fishery impaired during implementation -high impacts to amphibians -high impacts to water birds -requires introduction of new species in wilderness -not typical habitat for species (pike or muskellunge), clear cold lakes, deep water, little cover, only trout to eat, high altitude, short growing season -does not work well in streams -does not meet project goals -could impact non-target species like endangered bull trout
Rotenone	-proven technique - complete or near complete removal of compromising genetic material -requires only 4 days to complete -can be controlled with potassium permanganate -fishery restored in 1-3 years -naturally detoxifies with UV light, oxidation, dilution -works well in lakes and streams -no long term impacts to non-target organisms	-not as socially acceptable as other methods -bulky, large quantity -fish may smell/taste it and try to avoid, may succeed -short term affect on non-target organisms (insects, plankton, possibly amphibians)
Antimycin	-proven technique -complete or near complete removal of compromising genetic material -requires less volume than other piscicides -rapidly degrades with exposure to UV light -two components, inert until mixed -naturally detoxifies with every 200 feet of drop in stream elevation -requires about 4 days to complete -fish cant smell it, cant avoid it -toxic to fish in very low concentrations -does not affect amphibians at fish killing concentrations -easily packed to remote areas by mule -can be contained with potassium permanganate -fishery restored in 1-3 years -works well in lakes and streams	-not as socially acceptable as other methods -short term effects on plankton, insects

Based on the findings of this analysis, MFWP has determined that antimycin and liquid formulated rotenone offer the highest probability of success at completely removing the exotic trout, from both lakes and streams, in the shortest amount of time, with the least amount of impact to the ground and the aesthetics of the project sites. For these reasons toxicants have been developed for further consideration as a preferred method to achieve the goals of the project

Although toxicants offer the highest level of success at removing exotic trout in the shortest period of time, if the treatment of any lake is not completely successful, as determined by follow-up gill net surveys, it will be necessary to treat the lake once again in order to achieve the objectives of the project.

There are 13 lakes in this project in which bull trout populations reside in the drainages downstream (Table 5). The remaining 8 lakes either have few bull trout, the bull trout downstream reside in Hungry Horse Reservoir, or the treatment can be contained well before it reaches bull trout waters. It will be necessary to safeguard downstream bull trout populations while removing as many hybrid trout from those streams as possible. It is understood that safeguarding bull trout populations from a toxicant application may not allow all hybrid trout in a stream to be removed. The lakes that have bull trout populations downstream of them include Wildcat, Sunburst, Woodward, Necklace (4), Lena, Lick, Koessler, George, and Pyramid. Although there are no bull trout in Graves Creek downstream of Handkerchief Lake, it will be necessary to protect any bull trout that may be residing at the mouth of Graves Creek in Hungry Horse Reservoir. Eleven of these 13 lakes are located in the Bob Marshall Wilderness. There are three reasons why antimycin would be used for these 13 lakes rather than Prenfish. First, the ability of antimycin to naturally detoxify with every 200 feet of elevation drop makes containment easier. Second, antimycin requires a much lower quantity to effect fish kills than Prenfish, which makes transporting less volume of material into a remote area easier. Finally, because motorized access to wilderness lakes is only permitted when absolutely necessary, livestock would be needed to transport the materials to the project sites. The lower quantity of material would make transporting with traditional means possible, and would support wilderness values. George and Lick lakes are two wilderness lakes that have no trail access, and will require transporting materials with a helicopter.

Table 5. Elevation differential, distance to bull trout populations and values for natural detoxification using antimycin in lakes with downstream bull trout populations.

Lake	*Lake elevation*	*Distance to downstream bull trout (mi)*	*Elevation at downstream bull trout (ft)*	*Elevation diff from lake to bull trout population*	*Detox factor (elev diff ÷200ft)*
Wildcat *	5,810	3.46	4,040	1,770	8.9
Handkerchief*	3,835	1.33	3,560	275	1.4
Sunburst	5,322	7.54	4,160	1,162	5.8
Woodward	6,433	7.73	4,420	2,013	10.2
Necklace (4)	6,480	6.92	4,420	2,060	10.3
Lena	6,732	9.26	4,420	2,312	11.6
Lick	5,984	3.23*	5,280	704	3.5
Koessler	6,010	0.93	5,340	580	2.9
George	7,115	3.92	5,240	1,875	9.4
Pyramid	6,927	5.21	5,480	1,447	7.2

* lake located outside of wilderness

To determine the level of natural detoxification available, the elevation differential from each lake to the downstream bull trout population was calculated, then a detoxification factor was calculated based on 200 foot elevation intervals (Table 5). Each 200-foot interval represents one complete detoxification based on studies conducted by Tiffan and Bergersen (1996). Detoxification factors for these 13 lakes range from 1.9 to 10.6 times more than is necessary.

Because antimycin detoxifies naturally with elevation drop, it will be necessary to install recharge stations in streams below certain lakes to maintain lethality down to the treatment boundary. This will aid in removing as many of the hybrid trout as possible while still allowing a safe buffer for bull trout populations downstream. In addition, detoxification materials will be on hand and ready to implement to ensure the containment area is maintained. Each lake treatment will have a defined treatment area that describes the length of stream that will be treated and the downstream boundary. From that point on, the stream will not be treated with toxin. The amount of antimycin needed to treat each of the 13 lakes was determined from volumetric calculations gathered from TIN bathymetric statistics (Table 6). A complete description of each lake treatment is provided in a later section.

Table 6. Size and volume of lakes in which antimycin will be used, amount required for trout removal, and lake pH.

Lake	*Size (acres)*	*Volume (acre ft)*	*Number of antimycin units @ 7.5 ppb conc.*	*Lake pH*
Wildcat*	40	2,066	404	7.7
Handkerchief*	51.3	811	159	6.8
Sunburst	148.5	12,687	2,537	7.2
Woodward	65.0	2,255	451	6.7
Necklace (4)	42.2	323	64	6.5
Lena	74.2	2,547	507	7.0
Lick	19.0	141	28	7.1
Koessler	86.5	5,731	1,146	7.0
George	119.5	13,475	2,695	6.8
Pyramid	8.9	191	38	6.2

* lakes located outside of wilderness

Rotenone does not detoxify with elevation drop as quickly as antimycin. The fact that rotenone stays toxic in a stream environment longer than antimycin makes it better suited for removing fish from the streams below lakes with no downstream bull trout concerns. Eight of the 21 lakes in this project have no immediate downstream bull trout concerns, making it possible to completely remove hybrid trout from the streams below them (Table 7). There are three methods that will be used to detoxify rotenone; 1) dilution by freshwater inputs, 2) oxidation from natural substances in the stream beds (algae, gravel, sand, wood), and 3) use of a detoxification station to administer potassium permanganate. A detoxification station will be used on all rotenone projects unless on-site bioassays and current flow data indicate the compound will be reduced to sub-lethal levels without potassium permanganate. Each lake and stream system will be evaluated prior to treatment to determine the best containment strategy. Each lake treatment will have a defined treatment area that describes the length of stream that will be treated and the downstream boundary. From that point on, the stream will not be treated with toxin. A complete description of each lake treatment involving rotenone is provided in a later section.

Table 7. Size and volume of non-wilderness lakes, and Prenfish required for trout removal.

Lake	*Lake size (acres)*	*Volume (acre feet)*	*Gallons of Prenfish req'd*	*Total weight of Prenfish (lbs)*
Clayton	62	6,948	2,316	22,697
Blackfoot	16.5	205	68	667
Black	49.1	4,493	1,497	14,660
Upper 3 Eagles	10.8	487	162	1,588
Lower 3 Eagles	8.7	255	75	735
Pilgrim	29.9	2,528	842	8,258
Bighawk	27.3	612	204	1,999
Margaret	46.5	1,962	654	6,409

Methods of Transportation

The materials required to implement this project comprise the bulk of transportation needs. With the exception of George and Lick lakes, all of the proposed lakes that occur in wilderness have a trail suitable for access by livestock. Livestock are prohibited in the Jewel Basin Hiking Area, and the lakes within that area do not have maintained access trails that would support livestock. The lakes that occur on National Forest (Margaret, Handkerchief) have trail access or road access. The methods of transportation considered for this analysis include backpack by humans, livestock, truck, helicopter and SEAT airplanes.

Back packing

Although minimal, backpacking has been used to transport Prenfish to project sites in the Flathead basin. In 1999 MFWP personnel packed six gallons of Prenfish and a drip station into Hidden Lakes to recharge the Little Bitterroot River during the treatment of Hubbart Reservoir and Hidden Lakes. Due to the volume of materials and associated equipment necessary to apply and mix antimycin and Prenfish, backpacking would not be a viable method for transport. Rather, this method will be used to transport small quantities of antimycin and Prenfiswh to recharge stations on several outflow streams.

Livestock

This is a viable method of transport in areas that have an improved trail. All lakes listed in this proposal that occur in the Bob Marshall Wilderness have maintained trails with the exception of Lick and George lakes. Those that occur on National Forest and in the Jewel Basin Hiking Area do not have improved trails that would support livestock use. In 1994, livestock were used to pack 10 gallons of Prenfish, equipment and personnel into the Bob Marshall Wilderness to remove brook trout from Devine Lake. Based on this information, livestock will be used to transport materials, personnel and equipment to all lakes that occur in wilderness with the exception of George and Lick lakes.

Truck

Handkerchief Lake is the only lake with road access. A truck will be used to transport materials, equipment and personnel to this lake.

Helicopter

From 1986 to 2000, helicopters have been used to transport liquid formulated rotenone, personnel and equipment to treat 8 lakes in remote areas in the Flathead Basin. Those used have included a Bell 47, Bell 206 and a Hughes 500. The helicopters that would be used in this project would be those operated by MFWP and include two Bell OH58's and a Hughes 500. Loads of up to 800 pounds can be sling-loaded under these ships. Depending on the amount of fuel on board and air temperature, this amount of weight may be increased to 950 pounds. An electronic cargo hook on each ship allows them to drop loads without landing. Each ship can transport three passengers per trip. One of the MFWP OH58 helicopters has floatation struts, which makes landing on water possible. Given this capability, loads can be transported to lakes that do not have landing zones and the helicopter can land on the water to drop off personnel and pick up loads near the shoreline.

Helicopters have been used to dispense rotenone in small high mountain lakes (AFS 2002). A helicopter spray unit was used to apply Prenfish to marshy areas of Rogers Lake, Montana in 1993. Although the project was successful, it has not been considered as a viable application tool since because rotor wash from the helicopter caused the Prenfish to become aerosol and made application unsafe for personnel.

Based on the proven success of this transport method and the lack of trails that would support livestock in some areas, helicopters will be used to transport materials, personnel and equipment to all lakes outside the wilderness with the exception of Handkerchief Lake. Because there is no trail network to George and Lick lakes in the Bob Marshall Wilderness, a helicopter would be used to transport materials, equipment and some personnel to these lakes.

SEAT aircraft

Single Engine Air Tanker (SEAT) aircraft could be used for transporting and applying a portion of Prenfish. Unlike traditional large multi-engine fire retardant bombers, SEAT aircraft are small planes that have been designed specifically for fire suppression and agricultural applications (Mielec 1999). These aircraft are approved by the Federal Aviation Administration (FAA) under restricted category for fire fighting and agricultural operations (Mielec 2001). Available for use are M18B fixed-wing air tankers with a tank capacity of 500 gallons. They have a wing span of 58 feet, are 31 feet long, and have a single 1000 horsepower 9 cylinder radial engine. These aircraft are sufficiently agile and mobile and can apply Prenfish from the air on lakes larger than 10 surface acres. Dromader aircraft have delivered aerial applications for agriculture and fire fighting in 23 countries including North America (Bycan-Sellen Associates, Inc.1999). In Europe, Spain, France and Greece, these aircraft are used primarily for fire fighting (Erdberg 2000).

SEAT aircraft can vary the salvo rate of their payload, which can range from full release in as quick as two seconds to partial release over multiple passes. At full salvo, 500 gallons of fire retardant can be applied to an area approximately 60 feet wide by 250 feet long (Andy Taylor, Taylor Aviation, personal communication, 2001). This coverage area can be reduced if the load is partially released over multiple passes. Typical drops are conducted at 40-60 feet altitude and 80 knots (90 mph) airspeed (Mielec 1994). A computerized gate system controls the length of time the gate is open which consequently controls the volume of liquid that is released.

SEAT aircraft were developed, and operators must possess the skills, to suppress fire on an individual tree in complex terrain. SEAT aircraft operators, engaging in fire suppression in a theater where multiple aircraft are deployed and visibility is greatly obscured by smoke, must have additional skills beyond the operation of the airplane. The most important of these is the ability to visualize the location of all the other aircraft in relation to the fire solely by radio communication. They must also be able to locate and positively identify a precise target for the retardant that has been only described over the radio, while under some time pressure.

The U.S. Department of Interior, Office of Aircraft Services (OAS) annually contracts with pilots for SEAT fire suppression. OAS, together with their interagency partners in the fire fighting community, have set the standards for pilots to meet before being considered for government fire-suppression contracts. Pilots under contract with OAS must possess the following:

- 1,500 hours total in all aircraft,
- 1,200 hours in airplanes,
- 100 hours in airplanes during the preceding 12 months,
- 25 hours in make and model to be flown,
- 10 hours in the last 60 days,
- 200 hours in low-level agricultural dispensing operations,
- 200 hours over typical terrain (hazardous/mountainous), and
- 5 hours in each make and model to be flown each calendar year including:
  - five takeoffs and landings,
  - and making two drops of fire suppressant material on an individual target (tree, barrel or tire, at the inspector's discretion) generally from an altitude of 50 feet.

In addition, SEAT operators must comply with FAA regulations in 14 CFR (Certified Federal Register), 137(all) for agricultural operations, in conjunction with 14 CFR 91(where applicable). In order to apply rotenone from the air, an operator must be certified to operate agricultural aircraft and certified to apply economic poisons (pesticides, fertilizer, herbicides).

The level of precision necessary for application of agricultural chemicals and suppression of fire on an individual tree, as well as ability to operate in a complex theater, are well within the necessary skill parameters for Prenfish application on a lake. With such a high level of assured skill, the probability of missing a lake target during the application of Prenfish is extremely low to non-existent. The primary reason for this is the fact that a lake provides a definite target of great size for SEAT pilots to hit.

According to Mark Bickham, SEAT Program Coordinator for the Bureau of Land Management (BLM), the primary cause of retardant aircraft misplacing loads is misdirection by ground personnel. Retardant pilots drop their loads where ground personnel instruct them. Ground personnel occasionally misdirect pilots causing drops to occur in areas that are not intended. A target that is unmistakable, like a lake, would ensure no misplacing of Prenfish during aerial transport and application. Furthermore, pre-application flyovers would ensure that SEAT pilots are at the correct site before dropping their load. GPS navigation, landmarks, and communication with ground personnel further ensure proper site delineation. According to Bob Carr, contract officer for OAS in Boise, Idaho, aircraft traditionally used as fire retardant bombers are actually large retired military bombers or cargo planes that were not developed specifically for fire suppression. Unfortunately, ill-performance and structural failures of these aircraft have given a mis-perception to all fire suppression aircraft. The fact that SEAT aircraft are smaller, more agile, and are specifically designed and manufactured for fire suppression (Mielec 1999), makes them better suited for tactical, precision drops of fire retardant, or any other material.

SEAT aircraft first began service in government fire suppression in 1989 when 15 were contracted. This number has progressively increased to 57 in 2002 (Bill McCaulley, OAS, personal communication). Since 1998, OAS has contracted 11,940 hours of SEAT aircraft for fire suppression (Carr 2002).

Throughout the process of considering SEAT aircraft for use in this project, OAS was consulted about many safety and technical aspects. With regard to what type of SEAT aircraft and which aviation company could best perform this work, OAS indicated that a Montana-based company owned by Andy Taylor (Taylor Aviation Inc., and New Frontier Aviation Inc.) was rated in the top 2 or 3 in the nation for SEAT operation (Bill McCaulley, OAS, Boise, personal communication, 2001). Furthermore, Taylor is among the contractors listed by the Montana Department of Administration as Qualified Vendors for Montana State flight operations. Since 1995, Taylor has held more than 11 different contracts with OAS, and has provided up to 7 aircraft, support equipment and pilots for use by the federal government (Carr 2002). Additionally, Taylor has been contracted 11 times by the states of New Mexico, Wisconsin, Pennsylvania, and Montana for SEAT aircraft. Fire Operations Managers and Fire Support Coordinators from Montana, Utah, Nevada, Colorado, Texas, Idaho, and Oregon that were listed as references for Taylor were questioned about his ability and the performance and safety of the Dromader aircraft in the terrain of the South Fork Flathead. All of the references that were checked concurred that Taylor Aviation was capable of performing this type of work safely and effectively.

In October 2002 MFWP conducted drop experiments with Taylor Aviation at the Fort Benton Air Field. A Dromader M18B (tail number N455TG, FAA card # 455) was flown at a mean altitude of 32 (28-36) feet at 80 knots (90 mph) and released 4 loads of water over the airstrip. The wetted area created by the water on the airstrip was measured. The area of coverage from a release of 166 gallons of water was 239 feet long by an estimated 45 feet wide. The area of coverage from 250 gallons was 273 feet long by 45 feet wide. A second 250 gallon drop measured 294 feet long by 51 feet wide, and a 332 gallon drop measured 310 feet long by 88 feet wide. A slight crosswind was present during the experiment, causing some drift of water, and is accounted for in the width measurements. The liquid formulation of rotenone has a petroleum emulsifier added and it weighs 9.8 pounds per gallon versus 8 pounds per gallon of water. Based on this, pilot Andy Taylor added “the petroleum emulsifier would flow from the drop gate on the aircraft quicker than water…second, because Prenfish is heavier than water it would drop from the aircraft quicker making the area of coverage smaller”. Given these two variables, Prenfish would be expected to cover an area less than that measured during tests that used water as a surrogate material. Linear regression analyses of the data indicate there is a positive relationship ($r^2 = 0.90$) between the length of coverage and amount of water dropped from a Dromader aircraft (Figure 7). This suggests that there is a high level of consistency with the length of coverage of a typical Dromader drop. The regression equation used to determine the length of coverage of a typical Dromader drop was $y=0.4283x + 172.13$. The influence of a cross wind on the width of a drop precluded regression analyses of that variable.

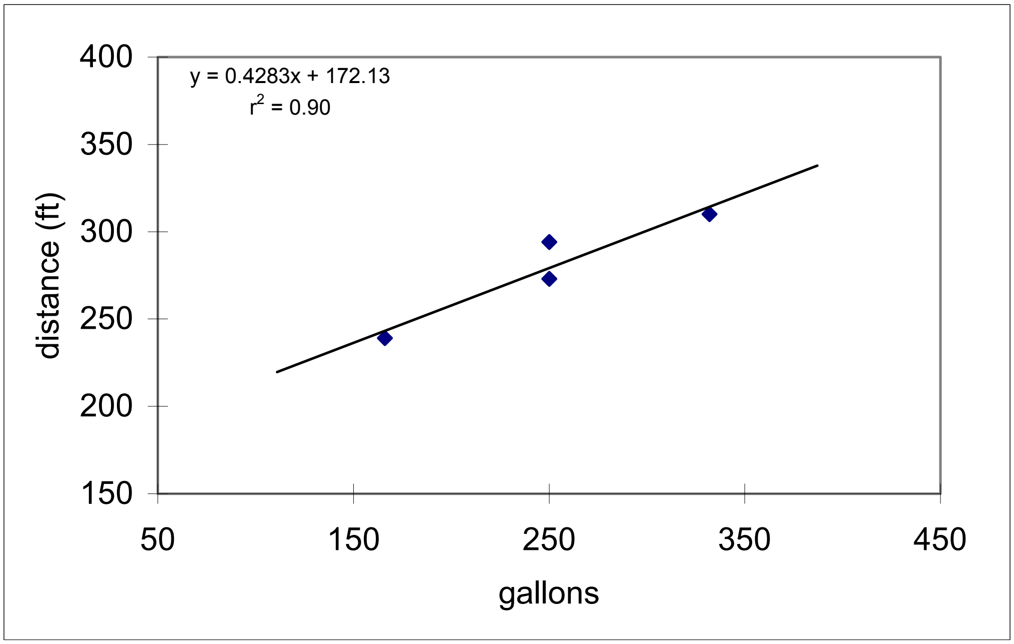

Figure 7. Regression plot of linear coverage and gallons of water released from a Dromader M18B flown at 80 knots and a mean altitude of 32 feet, Fort Benton, Montana, October 4, 2002.

A paved airstrip is required for SEAT aircraft so they would be staged from the Glacier International Airport in Kalispell. Taylor Aviation is equipped with a complete compliment of mobile support equipment necessary to load Prenfish onto the plane. One 1,600 gallon tanker truck with a 525 gallon trailer tank would be staged at the USFS fire retardant loading pad near Edwards Jet Center at the Glacier International Airport. The day before the treatment, the Prenfish would be pumped from 30 gallon barrels into the tanker truck. This truck and associated pump equipment can fill the 500 gallon tank on the SEAT in under 4 minutes. The aircraft would be filled with the desired amount of Prenfish and flown to the target lake, where it would be administered over a designated number of passes (determined by the size of the lake). If necessary, upon returning to the airport, the SEAT could be loaded in under 4 minutes and return to the lake for the next drop. The USFS retardant loading pad is equipped with two 10,000-gallon water tanks. Water from these tanks, mixed with potassium permanganate, would be used as a contingency if an accidental spill occurs at the loading facility. Upon completion of the application, all tanks, including that on the aircraft would be filled with water. Potassium permanganate would be added and allowed to set for 8 hours in order to neutralize residual rotenone. The neutralized water could then be disposed.

In September 2002, the four lakes (Clayton, Black, Pilgrim, Margaret) that are candidates for SEAT application were pre-flown by Taylor Aviation and a project fisheries biologist in a Beechcraft Baron to determine any limitations with this method. Factors like target size, an adequate approach to the target, an adequate exit route, landscape features that could be obstacles, probable wind currents, wind strength and wind direction were evaluated at each lake. During this flight, pilot Andy Taylor determined that the landscape features surrounding Margaret Lake may preclude safe application using SEAT. The remaining lakes were found to have suitable conditions for access and application using SEAT. Immediately prior to the application of Prenfish, while the plane is loaded, the lakes would be flown over twice in order to positively identify the target, test weather conditions and to establish clear communication with ground personnel. An application where SEAT aircraft are employed would only be conducted if the aircraft is able to administer its load. If weather conditions preclude application that day, it would be postponed until weather conditions improve.

In November 2002, the four lakes were flown a second time in a Hughes 500 helicopter with FWP pilot Lee Anderson, SEAT pilot Andy Taylor and a project fisheries biologist. A flight plan was developed that included alternative routes, application strategies and to rule out limitations using this method. Using the flexibility of the helicopter, several mach flights were flown to determine the safest route for approach and exit at each lake. During this flight, it was determined that all candidate lakes including Margaret Lake could be accessed with a SEAT.

Performance data for the Dromader M18B, provided in the manufacturers flight manual, indicate this aircraft is capable of a gross take-off weight of 11,700 pounds (Bycan-Sellen assoc. 1997). Dromader owner /operator Andy Taylor indicated that empty weight of his M18B model Dromaders ranges from 5,900 to 6,300 pounds. Loading calculations provided by Taylor indicate that each plane would carry a maximum of 480 pounds of fuel (80 gallons at 6 pounds per gallon), 170 pounds for a pilot, and 4,500 pounds of payload (460 gallons of Prenfish at 9.8 pounds per gallon). Based on this, the maximum gross weight of a Dromader M18B during this type of application would be 11,360 pounds, which is within the specified performance range for this type of aircraft.

If SEAT aircraft were used, their role would be to transport and administer a large portion of the Prenfish to the surface of the lake. Because the Prenfish would be concentrated at the surface, concentrated surface water would be pumped to deeper depths to effect proper mixing. In addition, motorized boats would be used to mix the compound while administering the other portion of Prenfish along the shoreline, and at deeper depths. Because a typical application by boat requires approximately 30 minutes to apply 30 gallons of Prenfish, a major advantage to using SEAT aircraft is the time savings afforded by administering large quantities of material in a short period of time. A typical SEAT load is approximately 500 gallons, which is the equivalent of 17 barrels. The same load would require 9 trips with a helicopter to transport. In the case of Clayton Lake, the amount of Prenfish transported and administered by SEAT would require a helicopter to transport 67 barrels (33 loads), leaving a boat to apply them at the rate of 1 every ½ hour. This would require approximately 33.5 hours for application alone. Second, finding a suitable storage area at Clayton Lake for 67 barrels would be difficult if not precluded.

Based on the information provided by OAS, BLM SEAT Program Coordinators, SEAT pilot Andy Taylor, references regarding Taylor's safety record, accuracy of SEAT aircraft, the time savings for transport and application using SEAT, the coverage data collected during drop tests, and information collected during the September and November 2002 flyovers, SEAT aircraft will be used in combination with a helicopter to transport Prenfish to Black, Pilgrim, Clayton, and Margaret lakes. SEAT aircraft will apply a portion of the Prenfish on these lakes in concert with a motorboat. Surface water will be pumped to deeper water zones of the four lakes to facilitate mixing.

Summary and conclusions

After completing the analysis of transportation methods considered for this project, the following summary has been prepared (Table 8):

Table 8. Summary of transport methods evaluated to implement the South Fork Flathead westslope cutthroat trout conservation program.

Method	Advantages	Disadvantages
Livestock	-may be more socially acceptable over other methods -proven technique for packing small quantity of material	-high impacts to trail and surrounding area -more time required to transport -requires storing materials on site for extended periods -potential conflict with other trail users during hunting -risk of accidental spill -requires maintained trail network

Table 8 (cont'd)

Helicopter	-great time savings -no disturbance to trails and ground -does not require storing materials for extended periods -proven technique within project area	-may not be as socially acceptable as other methods -possible risk of spill, but not probably
SEAT	-great time savings -no disturbance to trails or ground -transport high volume of material in one trip -reduces number of helicopter trips -high skill level, high probability of application success -allows for application where material cannot be stored on site	-may not be as socially acceptable as other methods -perception that plane may miss target -has never been used for this type of application -possible risk of spill, but not probable

The two primary considerations with transport methods are the type and amount of materials needed to achieve the objectives of the project, and the access restrictions that apply in hiking areas and wilderness. After evaluation of these considerations, it has been determined that all four methods of transportation will be employed. Following this evaluation, lakes were separated into three categories based on land classification, type of fish toxin, and transport method. The three categories are: 1) wilderness lakes being treated with antimycin and transported with livestock, 2) non-wilderness lakes being treated with Prenfish and transported with aircraft, and 3) both wilderness and non-wilderness lakes being treated with antimycin and transported with aircraft or truck.

<u>Wilderness lakes being treated with antimycin and transported with livestock</u>

In an effort to promote wilderness values, livestock will be used to transport the bulk of materials, supplies and personnel into 9 of the wilderness lakes, because they have suitable trials (Table 9). A detailed description of each treatment is provided in a later section.

Table 9. Wilderness lakes that will require livestock to transport antimycin, amount of material, number of animals needed, and trail distance.

Lake	*Volume (acre ft)*	*# of antimycin units @ 7.5 ppb conc.*	*Total weight of antimycin (lbs)*	*Livestock to pack antimycin*	*Pack distance (miles)*	*Starting trailhead*
Sunburst	12,687	2,537	9,513	55	10.4	Bunker
Woodward	2,255	451	1,691	10	11.2	Owl ck
Necklace (4)	323	64	240	2	10.1	Owl ck
Lena	2,547	507	1,900	11	13.9	Owl ck
Koessler	5,731	1,146	4,298	25	14.9	Owl ck
Pyramid	191	38	143	1	4.6	Pyramid

Non-wilderness lakes being treated with Prenfish and transported with aircraft

Helicopters will be used to transport materials, supplies and some personnel to 8 of the non-wilderness lakes (Table 10). Reasons for this include the lack of suitable trail networks that will support livestock and/or the fact that livestock are prohibited in the Jewel Basin Hiking Area. A SEAT airplane will be used to transport and apply a large quantity of Prenfish to Clayton, Black, Pilgrim and Margaret lakes. This will save a substantial amount of time in application, and ensure the application will occur in a single day. The fact that SEAT can apply Prenfish eliminates the need to store large quantities of material on site.

Table 10. Non-wilderness lakes that will require aircraft to transport Prenfish, amount of Prenfish needed, and number of flights.

Lake	*Volume (acre feet)*	*Gallons of Prenfish req'd*	*Total weight of Prenfish (lbs)*	*Helicopter flights for material*	*SEAT flights*
Clayton	6,984	2,328	22,814	4	4
Blackfoot	205	68	667	2	---
Black	4,489	1,496	14,660	8	2
Upper 3 Eagles	487	162	1,591	2	---
Lower 3 Eagles	255	75	735	1	---
Pilgrim	2,526	842	8,252	4	1
Bighawk	612	204	1,999	3	---
Margaret	1,962	654	6,409	2	2

Both wilderness and non-wilderness lakes being treated with antimycin and transported with aircraft or truck

Two of the non-wilderness lakes will require treatment with antimycin, which can be transported with a helicopter (Table 11). Reasons for this include the absence of a suitable trail network, which precludes livestock use. Handkerchief Lake will also require treatment with antimycin, but can be accessed by road. A truck will be used to transport materials to this lake. Lick and George lakes are located in the Bob Marshall Wilderness. Due to the lack of a trail to these lakes, a helicopter will be used to transport materials, equipment and some personnel to each lake.

Table 11. Wilderness and non-wilderness lakes that will require aircraft and automobile to transport antimycin, amount of antimycin needed, and number of flights or loads needed.

Lake	*Volume (acre ft)*	*Number of antimycin units @ 7.5 ppb conc.*	*Total weight of antimycin (lbs)*	*helicopter flights for antimycin*	*Number of truck loads*
Wildcat	2,066	404	1,515	2	---
Handkerchief	811	159	596	---	1
Lick	141	28	105	1	---
George	13,475	2,695	10,106	12	---

Backpacking by humans will also be used in combination with all methods in order to access remote areas that will require recharge stations and detoxification stations.

Amphibians

In 2001, MFWP, in cooperation with the USFS Region 1, commissioned a study to survey the presence and distribution of amphibians in the project area with a particular focus on the lakes listed in this project (Maxell 2002). Four amphibian species and two reptile species were detected in the project area; long toed salamander (*Ambystoma macrodactylum*), Rocky Mountain tailed frog (*Ascaphus montanus*), western toad (*Bufo boreas*), Columbia spotted frog (*Rana luteiventris*), western terrestrial garter snake (*Thamnophis elagans*), and common garter snake (*Thamnophis sirtalis*). Four other species are believed to occur in the project area, but were undetected; pacific tree frog (*Psuedacris regilla*), northern leopard frog (*Rana pipiens*), western painted turtle (*Chrysemyus picta*), and rubber boa (*Charina bottae*). The western toad and northern leopard frog are the only species in the project area that are considered sensitive by the Montana Natural Heritage Program.

Baseline information gathered from past surveys (USFS 1999) and continuing MFWP surveys indicates that these species are distributed throughout the Swan Mountain range within the proposed study area. The wide abundance and diversity of habitat identified by Maxell (2002) suggests that the spatial distribution of these species collectively represents a stable ecosystem. Maxell surveyed all 21 of the lakes listed in this project and found that amphibians occurred at 13 of them. Of the 8 lakes where amphibians were not detected, 5 of those lakes had amphibians detected within a mean distance of 0.8 mile (0.6-1.3) (Table A1). Maxell reported that detection of amphibians in this study may have been influenced by the fact that each site was visited only once, and that some of these lakes lacked suitable habitat to support amphibians. Given that lake habitats are used for different life history stages (breeding, rearing, over wintering) throughout the year, detecting any one life history stage during a single visit may be difficult. For example, a lake used by Columbia spotted frogs for over wintering may only have frogs present from September to June. If this lake were surveyed in July, there may be none present. To evaluate this further, in 2002 MFWP surveyed 21 lakes and streams in the Kalispell area that had previously been treated with rotenone, to evaluate recolonization and temporal use by amphibians (Table A2). Three of the 21 waters demonstrated this phenomenon in which amphibians were detected in early summer, then not detected in late summer. Conversely, amphibians were not detected at some sites in early summer, but were detected in the late summer. In the case of Hubbart Reservoir, an estimated 200,000 western toad tadpoles were observed in August, but in September they were virtually absent. Further investigation revealed that the bulk of these tadpoles had apparently metamorphosed and demonstrated an ontogenetic niche shift by migrating several miles upstream into the Little Bitterroot River corridor. Previous surveys in the Little Bitterroot River area did not detect any western toad tadpoles or juveniles. A second example of this occurred at Lion Lake when, in June and July, no amphibians were detected, but by August and September, Columbia spotted frog juveniles were observed. This suggests that a similar niche shift occurred during the latter part of the summer. In both cases however, if only a single survey had been conducted at each site, erroneous conclusions could have been made regarding the value of either system as amphibian habitat.

In addition to the numerous lakes in the South Fork Flathead drainage, there are 1,898 miles of stream and riparian habitat that are virtually unsurveyed for amphibians. MFWP file data indicate that during electrofishing surveys conducted on 14 tributary streams to Hungry Horse Reservoir personnel have frequently encountered amphibians each year since 1987 (Table A3). Most of these observations were of tailed frog tadpoles, but some adults were observed, as well as other species. Although tadpoles were not quantified, fisheries personnel have characterized them as "abundant" during these surveys. These data were summarized from notes of observations on historical fish survey data sheets. Although some years reflect no amphibians, this could mean that amphibians were observed but not recorded. In streams and lakes throughout the South Fork Flathead, westslope cutthroat trout and amphibians would be expected to co-exist much as they do naturally in these streams.

As previously discussed in the section on rotenone, there have been seven high altitude mountain lakes in the Flathead basin in which liquid formulated rotenone was used to remove populations of unwanted trout. That discussion detailed the results of amphibian surveys before and after treatment, which revealed that amphibians are able to recolonize a lake within a short period of time following the treatment.

In addition to these seven lakes being treated with liquid formulated rotenone, they were also restocked with westslope cutthroat trout. Devine Lake, for example, was planted once with 1,140 westslope cutthroat trout fry in 1997. A survey of the lake in 2001 revealed eight adult spotted frogs. Fish were abundant in the lake. A survey in 2002 revealed a single adult spotted frog and over 50 spotted frog tadpoles.

The four Jewel lakes were treated with liquid formulated rotenone in 1986 to remove rainbow trout. East Jewel Lake was planted with 1,324 cutthroat trout between 1986 and 1988; North Jewel was planted with 6,056 cutthroat trout between 1986 and 1992; South Jewel was planted with 4,610 cutthroat trout between 1986 and 1989. West Jewel was not directly planted as fish from South and North Jewel lakes could swim into it. In 2001, a survey was conducted along the shore of each of the 4 lakes and found 26 frogs of both the spotted and tailed variety with both adults and juveniles present. A survey of the four lakes in 2002 revealed 76 spotted frog adults, 103 juveniles, over 110 tadpoles, and a single tailed frog adult. Amphibians were present at each of the four lakes.

Whale Lake was treated with Prenfish in October 2000 to remove hybrid cutthroat trout. It was planted in 2001 with 1,246 westslope cutthroat trout, 200 of which were between 4 and 11 inches in length. A survey in July 2002, approximately 21 months after the treatment, yielded 21 salamander tadpoles, many of which had not yet emerged from their gelatinous matrix. This survey was conducted on only ½ of the lake. Numerous fish were observed feeding at the surface of the lake. In September 2002, another survey found 16 salamander juveniles and a single tailed frog adult. In addition, small trout fry approximately 1-1/4 inches long were observed in the outlet stream, indicating natural reproduction had occurred. The outlet stream was dry approximately 100 yards downstream of the lake.

Tom-Tom Lake was treated with Prenfish in October 2000 to remove a population of hybrid trout. The lake was planted in 2001 with 2,000 genetically pure westslope cutthroat trout, 500 of which were 4 to 11 inches in length. The lake was surveyed in September 2001, approximately 1 year after the treatment, and surveyors netted over 25 long-toed salamanders in both larval and adult stage, over 100 juvenile spotted frogs, and 2 tailed frogs. A survey in 2002 revealed 115 spotted frog juveniles, a single adult, 2 long toed salamander juveniles, approximately 40 eggs. Five tailed frog tadpoles were found in the outlet stream.

Wheeler Creek is the outflow stream for Tom-Tom Lake. The stream was detoxified with potassium permanganate at the mouth of the lake during treatment. In July 2001, approximately 9 months after the treatment on Tom-Tom Lake, Wheeler Creek was electrofished at four different sites for 3.18 hours of total electrofishing, and 6 adult tailed frogs, 32 tailed frog tadpoles with specimens displaying developmental stages that included no legs, 2 legs, and 4 legs were collected. Many other tailed frog tadpoles were not netted due to swift flows and their ability to make a quick escape. Although not quantified, numerous stoneflies, caddis flies and dragonflies were also observed. A replicate survey in 2002 found 58 tailed frog tadpoles at the four sites during 3.37 hours of electrofishing.

These findings suggest that amphibians are not only able to withstand a rotenone treatment in high altitude lakes in the Flathead basin, but also the presence of westlope cutthroat trout likewise has little impact on the ability of these amphibians to recolonize and maintain a viable population. The long-term re-colonization of amphibians in a lake treated with rotenone appears to be uninhibited as evidenced by the Jewel lakes and Devine Lake examples. The restocking of fish in these lakes likewise has little apparent effect on the ability of amphibians to survive and re-colonize a lake that is treated with liquid rotenone.

Based on these findings, MFWP has determined that there is no evidence to suggest that rotenone treatments and fish stocking in the South Fork Flathead drainage have been destructive to amphibians.

<u>Monitoring</u>

Substantial evidence indicates rotenone and antimycin have no adverse effects on amphibians in the project area. If more than 1 mile of stream is treated with Prenfish, MFWP will collect tailed frogs from the first 1 miles of stream and secure them during the treatment. Shortly after the treatment is complete, the frogs will be replaced in the stream. This measure will ensure that no unforeseen impacts would depress the population beyond recovery.

Fish stocking

Once lakes are depopulated of fish, the decision whether or not to restock them lies solely with MFWP. The charter of MFWP is to provide a diversity and abundance of angling opportunities for the public. Pursuant to the Bob Marshall Wilderness Complex Management Framework Document, cooperation and input from the USFS will be given to determine the best management of the lakes that occur within designated wilderness. Throughout this environmental process, some interest groups have suggested that fish stocking should be discontinued in wilderness lakes, some have suggested that three of the project lakes should be left fishless, while others have suggested that stocking be deferred to monitor the effectiveness of removal programs, then stocked. Based on these comments, MFWP evaluated these suggestions and concerns.

Creating fishless lakes outside of the Bob Marshall Wilderness has been less of a priority for these interest groups, so focus of this analysis will be primarily on wilderness lakes. Reasons for not restocking lakes in the Bob Marshall Wilderness include:

- the belief that removing fish would be beneficial to bacteria, plankton, insect, amphibian and reptile species in wilderness areas,
- the belief that a true wilderness area must exhibit conditions that existed prior to European settlement of the United States, including no trails, no buildings, no bridges, no public landing strip at Schafer Meadow and no communication structures like repeater stations,
- the belief that deepwater lakes devoid of fish are necessary to provide a unique experience in the wilderness,
- the belief that a true wilderness should not be managed, but rather left to change only as natural processes dictate,
- manage wilderness use and site impacts through fish stocking (i.e. poor fishing or no fishing opportunities means use would decline).

<u>Partial restocking</u>

The primary reason given for maintaining three fishless lakes is that this action would provide unique deepwater environments for wilderness users to enjoy. The reason that three lakes were suggested is that this number represents approximately 10% of the total lakes listed in this project. There is little other information provided by these proponents that indicates this management strategy is necessary.

<u>Deferred restocking</u>

Others have proposed that fish stocking be deferred to evaluate how effective a chemical treatment is at removing 100% of the exotic trout. Proponents have suggested leaving a lake fishless and gill netting it for three years after the treatment to determine if chemical treatment was 100% effective. Thereafter the lake could be restocked. There are several reasons why this strategy may not be appropriate. There are compelling biological and social reasons for immediately restoring lakes with genetically pure westslope cutthroat populations following a removal project. First, despite the high probability of a complete removal using antimycin or Prenfish, there is a possibility of some fish eluding the treatment and remaining in a lake. If left unchecked, these few fish could re-establish a population in the lake, in which case removing hybrid trout would have not been accomplished. The lake would require treatment a second time. Second, from a biological standpoint, it would be necessary to restock these lakes to dominate and genetically dilute any remaining hybrid fish that may have escaped the treatment. This would provide a source of genetically pure fish to reseed streams below the lakes. Genetic analyses of downstream populations have demonstrated that exotic fish have been escaping from the lakes and residing in downstream locations. Surveys conducted in the South Fork Flathead in 2000 (Rumsey and Cavigli) revealed that outlet streams from six hybrid lake populations all contained hybrid fish for a distance of up to 4 miles downstream. The concept of fish invading stream networks following headwater lake stocking has been adequately described in Adams et al. (2001). Using this approach in reverse, we would depend on genetically pure fish in headwater lakes to re-populate these areas to move them toward a genetically pure state.

No restocking

Some people have suggested that fish should be removed from all of the project lakes and that they be left to a natural fate. There is a belief that water chemistry, and bacteria, plankton and amphibian populations would revert to a more-natural state. Despite reports of declining amphibian numbers, like yellow legged frogs in California (Pope and Matthews 2001), there is no evidence to indicate that amphibian populations in the Bob Marshall Wilderness are in decline or in jeopardy simply because they co-exist with cutthroat trout variants. Inventory studies conducted by Maxell (2002), USFS (1999) and MFWP indicate that native amphibians are widespread throughout the project area. There are 1,898 miles of stream and riparian habitat in the South Fork Flathead drainage that are virtually unsurveyed. Observations of amphibians made by fisheries workers incidental to fish surveys in some of these streams indicate that amphibians are abundant, even as they co-exist with cutthroat trout and highly voracious bull trout (Table A3). Fish stocking has occurred with much greater diversity of fish species and in much greater abundance in other wilderness areas than has occurred in the Bob Marshall Wilderness. Many fish removal programs in National Parks and other wildernesses have focused on removing nonnative species like rainbow and brook trout (Rosenlund and Stevens 1992; Moore et al. 2001; Knapp and Matthews 1998; Pilliod and Peterson 2000; Parker et al. 2001). The fish species in this project are westslope cutthroat trout hybridized with rainbow and Yellowstone cutthroat trout and sensitive amphibian species like the yellow legged frog are not present. The westslope cutthroat trout and amphibian species native to the South Fork Flathead drainage have co-existed for thousands of years. It is reasonable to expect them to continue to do so.

One argument has been that although westslope cutthroat trout and amphibians have co-existed in the Flathead drainage, they did not historically co-exist in the lakes listed in this project. Therefore an assumption has been made that the stocking of westslope cutthroat trout in historically fishless lakes has been environmentally damaging. In 2002, MFWP investigated food habits of westslope cutthroat trout in 4 lakes in the Flathead basin to determine use of amphibians in cutthroat trout diets. Trout, Lupine, Moose, and Rogers lakes were selected because they are known to be highly productive amphibian habitats. These lakes were surveyed each time to identify the abundance of amphibians. Fish were collected primarily by angling to reduce bias of regurgitation common with a traditional method of capture, like gill netting. Sampling occurred during July, August and September when tadpole abundance was at it's highest. All fish sampled had food items in their stomachs indicating regurgitation was not a factor. Stomach contents from 89 westslope cutthroat trout were collected from the four lakes over this time period. Although amphibian tadpoles and/or juveniles were present at each lake during each sampling period, none were found in any of the trout stomachs, at any time. Even though amphibians were available for food, the most common food items found in westslope cutthroat trout stomachs were: *Emphemeroptera, Trichoptera, Diptera, Odanata, Colioptera, Mollusca, Crustacea*, *Hirudinea, Zygoptera, Belostomatidae, Hemiptera*, zooplankton, terrestrial insects, Arachnids, and fish (Table A4). These findings suggest that amphibian tadpoles are not sought after as food items by westslope cutthroat trout even during periods of their highest abundance. During one survey on Lupine Lake in August 2002, technicians observed an estimated 5,000 to 10,000 western toad tadpoles, none of which were detected in fish stomachs. During the same observation, spotted frogs were observed feeding on western toad tadpoles. Laboratory necropsies of some of these frogs confirmed predation on western toad tadpoles.

Tyler et al. (1998) studied the effects of water chemistry, physical habitat and fish stocking on long-toed salamander populations in 45 lakes in the North Cascades National Park Complex in Washington. They reported that salamander distribution and abundance is influenced by biotic factors and abiotic factors other than fish. Primary among these was the concentration of total Kjeldahl nitrogen (TKN). Other factors like total phosphorus, water temperature and ammonium-N were positively correlated with TKN concentrations and lead the researchers to conclude that they likewise play a vital role in abundance of salamanders. Lakes with higher concentrations of TKN had statistically greater numbers of long-toed salamanders regardless of whether they contained fish or not.

Diatoms (microscopic water plants) are the most widely used group of biological indicators in paleolimnological research, and they are rapidly becoming a primary indicator group for several large scale and long-term biomonitoring programs of environmental change (Douglas et al. 1994). Douglas et al. (1994)

reported that unprecedented environmental changes, most likely related to climatic warming, have occurred since the beginning of the 19th century. Airborne pollutants and acid rain are alternative possibilities, but changes in the diatom record of lake sediments predated most of these anthropogenic influences. Researchers have studied the effects of fish stocking on lake diatoms and insects. Drake and Naiman (2000) collected lake sediments from eight high altitude lakes in Mount Rainier National Park to evaluate diatom and insect layers deposited over the past 480 years. From the geologic record, they observed several changes in diatom communities that were associated with fish introductions, but many shifts were also observed hundreds of years before European settlement. They reported that diatom community changes may result from things like fish introductions into fishless lakes, but the evidence indicates they may also result from natural processes as described in Douglas et al (1994). They reported that there were no consistent changes in the insect record that coincided with the introduction of fish. This lead to their conclusion that full ecological restoration will involve more than simply removing fish from a lake.

Luecke (1986) investigated the effects of cutthroat trout stocking on invertebrates in Lake Lenore, Washington, a previously fishless lake. Comparisons made before and after the introduction of cutthroat trout revealed few changes in the overall abundance of benthic invertebrates resulting from fish. A major change in the plankton community was directly related to the introduction of midge insect (*Chaoborus* spp.), which preys on other plankton, and was introduced prior to the trout. The most dramatic changes relating to the introduction of trout included reduction in numbers of certain species of plankton only in certain zones of the lake while others remained constant. Patterns of plankton vertical migration shifted presumably to allow them to avoid predation by fish. In conclusion, Leucke reported an anticipated return of plankton to pre-fish condition, after fish had more time to reduce the densities of introduced midges that prey on other plankton.

If MFWP were to depopulate a lake with the intent to keep it fishless, the history of illegal fish introductions in the South Fork Flathead warrants consideration of the potential for future illegal introductions, especially in lakes with a demonstrated angling popularity. There are at least six lakes in the South Fork Flathead section of the Bob Marshall Wilderness that have fish, but have no known legal stocking history. These are: Devine Lake, which prior to 1994 harbored a population of illegally introduced brook trout, Upper Marshall, Lower Marshall, Palisade, Hart, and Christopher. MFWP (1959; 1957) file records indicate that unauthorized parties stocked at least 7 lakes in the Graves Creek drainage with rainbow trout prior to 1957, and by 1965 the sources of rainbow trout stocking in the Big Salmon drainage were "unknown" (MFWP 1965). Future illegal introductions could involve exotic species and compound efforts to safeguard native fish. Illegal introductions of fish are common statewide.

The lakes in this proposal are often destination sites for wilderness users and currently provide angling opportunities for the public. Likewise, many lakes in the Bob Marshall Wilderness are used by outfitters for commercial enterprise. Depopulating a lake and not restocking it would impact these user groups and most likely place added recreational pressure on adjacent lakes. This could mean exceeding use standards set by USFS.

Since 1985, 1,014,889 genetically pure westslope cutthroat trout have been stocked in 46 lakes in the South Fork Flathead drainage, of which approximately 800,000 have been stocked into the 21 lakes listed in this project. This stock of fish has primarily come from the Washoe Park State Fish Hatchery in Anaconda. MFWP statewide angler pressure estimates from 1989 through 2001 were used as a tool to measure the level of use that the lakes in this project receive. These statistics are based on data gathered from anglers who voluntarily participate in the survey. Although empirical information suggests that some lakes receive more use than is reflected in these estimates, it is considered remarkable that a highly remote lake, like Lick Lake, appears in the survey. The lakes listed in this project receive an estimated 2,493 angler days per year (Table 12) (MFWP 2001b; MFWP1999b; MFWP1997; MFWP1995; MFWP1993; MFWP1991; MFWP1989). When considered as one fishery, they rank as number 160 out of 1,529 waters MFWP manages as fisheries. These statistics reflect only the lakes listed in this proposal. Including other popular South Fork fisheries like Spotted Bear and Big Salmon lakes would place this ranking even higher.

Based on this information, MWFP has determined that restocking all of the lakes listed in this proposal would help achieve the goals of the project while having little or no negative effect on the environment. The lakes would continue to provide angling opportunities for the public.

Table 12. Angler use estimates for select lakes in the South Fork Flathead River drainage, 1989-2001 and statewide rank based on 1,529 fisheries in the state.

lake	*1989*	*1991*	*1993*	*1995*	*1997*	*1999*	*2001*	*mean*	*Statewide rank*
Wildcat	181	74	40	148	39	90	214	112	886
Clayton	164	304	289	116	396	83	368	245	579
Blackfoot	1282	75	25	311	34	123	478	332	479
Black	48	89	199	196	135	38	41	107	912
Handkerchief	1096	327	632	703	573	660	924	702	320
Three Eagles (2)	---	---	---	---	---	---	---	---	---
Pilgrim	---	---	---	---	---	34	---	34	1404
Bighawk	---	99	---	44	38	---	---	60	1173
Margaret	288	56	105	250	108	42	36	127	846
Sunburst	103	49	115	175	39	45	149	96	965
Woodward	60	572	---	34	67	45	---	156	732
Necklace (4)	---	---	189	---	46	---	---	118	869
Lena	---	---	---	165	---	---	---	165	712
Lick	---	---	---	88	---	---	---	88	983
Koessler	---	---	---	---	---	---	---	---	---
George	60	76	---	180	---	---	---	105	923
Pyramid	72	37	25	---	---	83	69	57	1175
total								2493	157

Fishless lakes

Concerns have been expressed that resource managers for the Bob Marshall Wilderness need to provide deep fishless lakes for unique recreational experiences. In 2002 a survey of Rubble Lake in the upper Cataract Creek drainage confirmed that it is fishless. A bathymetric survey revealed the lake is 87 feet deep, has a surface area of 15.3 acres, and its volume is 570 acre-feet (Figure B30). Upper and Lower Terrace lakes were also surveyed in 2002 to confirm MFWP records that indicated the lakes were stocked in 1928 with rainbow trout, and again in 1946 with cutthroat trout. Gill netting in each lake did not catch any fish, nor was any evidence of fish observed. Upper Terrace lake has a maximum depth of 32 feet, has a surface area of 8 acres, and its volume is 102 acre-feet (Figure B31). Lower Terrace lake has a maximum depth of 34.4 feet, has a surface area of 8.3 acres, and its volume is 145 acre-feet (Figure B32). Despite being fishless, lower Terrace Lake harbors an abundant population of fresh water shrimp and has optimum spawning gravel at its inlet. These findings confirm that deep fishless lakes currently exist in the Bob Marshall section of the complex. Creating fishless lakes from those that currently harbor fish would only be to the detriment of the many anglers that utilize them for their wilderness experience. Furthermore, this would be counter productive in meeting one project objective, which is to provide a source of pure fish to dominate any possible remaining hybrids in downstream locations.

Some have proposed to reduce or eliminate public use of wilderness through eliminating fishing opportunities. Restricting public use through trail closures would be a more logical method of accomplishing this objective.

In 2002, several lakes in the Jewel Basin Hiking Area were surveyed to determine their present fishery status. Aeneas Lake was gillnetted and found to be fishless. The lake has a surface area of 2.7 acres, is 7 feet deep and has a total volume of 6.1 acre-feet. An unnamed lake located in the Clayton Creek drainage, 0.9 mile from Clayton Lake was gillnetted and found to be fishless. This lake has a surface area of 7.4 acres, is 30 feet deep, and has a total volume of 125.8 acre-feet (Figure B33).

Based on the information gathered from recent surveys, MFWP has determined that several lakes including Rubble Lake, the two Terrace lakes, and the unnamed lake in Clayton Creek provide unique deep water fishless environments for users to enjoy. In total, there are 298 fishless lakes (mean size is 1.3 surface acres, range 0.1-15.3) that provide a wealth of unique recreational opportunities. For this reason, the preferred alternative is to restock the project lakes with genetically pure westlope cutthroat trout to achieve the objectives of the project. Following treatment, each lake will be stocked with fish for three years to establish a population. Some lakes will be stocked with multiple sizes of fish to restore the fishery as quickly as possible. On year five post-treatment, the lake populations will be evaluated to determine if natural reproduction is occurring and at what level. Based on this, MFWP will determine future stocking needs, if any. Criteria that will be used to make this determination include: presence and level of natural reproduction, level of use by anglers, downstream needs for genetically pure fish, fish condition factor, and density (fish per net set). Although the preferred action would be to manage self sustaining populations where possible, it may be necessary to stock some lakes to maintain angling quality and population viability.

Summary and conclusions

There has been no evidence to indicate that fish stocking has been environmentally damaging in the South Fork Flathead. The existing deep fishless lakes provide users with a wealth of unique recreational opportunities. Finally, it is believed that fish stocking should not be used as a tool to manage public use of wilderness. Based on this information, MFWP has concluded that restocking all the lakes listed in this proposal will best accomplish the goals of this project, while maintaining angling opportunities for the public. It will be necessary to restock all of the lakes in order to ensure that any remaining hybrid trout in either the lakes or streams are highly influenced by genetically pure fish in order to prevent a resurgence of hybrid fish. Before each lake is re-stocked, a gill netting survey will be used to measure if a complete kill has occurred. If some fish remain, it will be necessary to treat the lake a second time to remove all of the fish.

Development and use of new strains of westslope cutthroat trout

Some groups have expressed concern about what type of westslope cutthroat trout should be used to re-stock a lake once hybrid trout are removed. The Conservation Agreement (MFWP 1999a) recommends:

…maintaining locally adapted, genetically pure populations…

The objective of this project is to maintain the genetic purity and diversity of westslope cutthroat trout in the South Fork Flathead River and in Hungry Horse Reservoir. In order to do this we will need to remove exotic and hybrid trout that are threatening these pure populations. In some streams, hybrid fish have not completely invaded the pure populations that reside in them. This has been beneficial in providing an apparent buffer between the hybrid trout being produced in headwater systems and genetically pure populations that reside in the river and reservoir. There is a belief that continued use of the M012 cutthroat will be genetically damaging to the South Fork Flathead ecosystem, and that only locally adapted fish from a specific or neighboring stream would provide the best conservation for the species in the South Fork Flathead drainage. There are several reasons why the nearest neighbor philosophy is not absolutely necessary or even practical for conservation of the South Fork Flathead cutthroat.

In a May 2002 (Leary) letter to the Montana Cutthroat Technical Committee, a University of Montana geneticist summarized the available genetic information from the South Fork Flathead drainage, and listed 38 genetically pure populations, and 11 drainages with one or more hybridized populations. Three of these; Big Salmon, Wheeler and Gordon creeks possess genetic material deemed worthy of conserving. Given that the pure westslope cutthroat tested from Wheeler Creek consisted of only 7 individuals, and hybrids have been tested upstream and downstream of the site where this sample was taken, it is highly unlikely that this is a viable, self sustaining, and randomly mating population that has not been influenced by exotic trout. Rainbow trout have been documented in the upper portions of Big Salmon Creek from 1965 to present (MFWP 1965). Numerous genetic tests confirm the presence of Yellowstone cutthroat trout hybrids in the Gordon Creek drainage. Therefore, propagating fish from those drainages for a conservation program would risk re-infusing these exotic trout genes in future populations. For this reason MFWP will not be propagating fish from those drainages for use in this conservation program. In his letter, Leary (2002) wrote:

> *…based on the existing genetic information collected from the South Fork Flathead River drainage… if within drainage transfers or drainage specific brood stocks are considered infeasible or impractical, then introduction of westslope cutthroat trout, regardless of origin, into the lakes is better than doing nothing since available data indicate the lake populations are serving as a source of downstream interspecific hybridization.…*

In addition to the risk of re-infusing exotic genes into a pure population, the following are logistical considerations that may preclude drainage specific stocks from being practical or feasible.

If drainage specific fish were used for lakes in the Big Salmon Creek and Gordon Creek drainages, this would require a hatchery facility capable of producing and maintaining two genetically distinct stocks of westslope cutthroat trout; one for Gordon, Koessler and Lick lakes, and one for Lena, Necklace and Woodward lakes. In order to maintain angling quality of the aforementioned lakes, the annual production needs for a Big Salmon drainage stock is estimated at 23,000 fish, and the needs for a Gordon drainage stock would be approximately 22,500 fish. At present the State of Montana has no facility that can contain multiple genetically distinct stocks of fish. There is some possibility of a facility like the Sekokini Springs Hatchery playing a role in this type of conservation effort, but it is not operational and is not expected to be until 2008.

Collecting live fish from a wild remote location for brood development may be problematic. Gordon Creek is between 13 and 18 miles from the Owl Creek trailhead. Capturing and transporting live fish by aircraft, or by mule out to the trailhead would be very difficult. Second, once wild fish are placed in a hatchery, domesticating them to a hatchery environment and hatchery food is difficult. During the acclimation of the State's current westslope cutthroat brood stock, an estimated 1/3 of the 4,600 fish taken from the wild died before they were acclimated to hatchery life (Mark Sweeney, MFWP, personal communication 2002). Stress from capture, movement and displacement often causes wild fish to die. Fish from Gordon Creek could be captured in the lower end of the drainage, packed by stock to Big Prairie, approximately 4-6 miles away, and flown out by airplane.

Capturing fish from Big Salmon Creek would be met with similar difficulties, but transporting them out of this remote area would require packing by stock approximately 15 miles to Owl Creek trailhead. It would be possible to land a floatplane or helicopter on Big Salmon Lake and transport live fish to a hatchery truck much quicker. In 1964 and 1965, MFWP landed a Bell 47 helicopter at the inlet of Big Salmon Lake where anglers caught westslope cutthroat trout for brood development. The fish were anesthetized, packed in ice and flown to a waiting hatchery truck in the town of Seeley Lake (Cliff Higgins, MFWP pilot-retired, personal communication, 2002).

A second option would be to trap migrating spawners from Big Salmon and Gordon Creeks and collect sperm and eggs. Because westslope cutthroat trout tend to spawn during high spring runoff, keeping a trap in a stream during high flows can be difficult to near impossible unless it is heavily fortified. One spawning trap used to collect westslope cutthroat trout during spawning season on Hungry Horse Creek required subterranean fortification with concrete. Likewise, fish traps on the Red Rock River near Dillon and Deep Creek near Townsend are fortified with concrete to efficiently collect rainbow trout eggs for hatchery needs. Westslope cutthroat spawning typically occurs in June. Given that most trail access in the backcountry is not possible until mid to late July, this method may be difficult if not precluded.

Electrofishing is a final option for capture, but would be very difficult if only eggs and sperm were sought during the spawning season. If only live adult fish were sought, they could be captured during periods of low water flow and transported out to a hatchery facility.

Before any wild fish, sperm or eggs can be moved into a Montana hatchery, they must be screened for disease. This typically requires a lethal sample of 60 fish. Next, these fish must be screened for genetic purity. Because genetic testing relies on analyses at the population level, these tests do not detect genetic purity of individual fish. This means that if genetic markers for exotic trout are detected in a single fish, the entire population is considered to have been influenced by exotic trout genes. Finally removing fish from a lowly populated wild stock for disease testing and for developing brood stocks may have devastating effects on the viability of that population.

Other options would be to re-establish a population of genetically pure M012 cutthroat in each of the lakes. Afterwards, fish from a donor population could be captured and held while genetic testing confirmed their purity. If these fish were pure, they could be infused into some of the headwater lake populations by simply moving the live fish to each of the lakes. Through time, some or all of the local adaptations sought by nearest neighbor conservationists would be manifested in each of the headwater lake populations. Using this method, managers could maximize the number of fish taken from the wild by reducing mortality and stress typically associated with transport and domestication to a hatchery environment. Furthermore, there would be little chance of loosing these local adaptations during the process of domestication to a hatchery if the process was circumvented and fish were moved directly from the source stream to the destination lakes. Doctor Lake is also in the Gordon Creek drainage and is believed to harbor an aboriginal community of westslope cutthroat trout, bull trout and mountain whitefish. MFWP records indicate the lake was stocked with 25,000 cutthroats in 1940. Genetic tests in 1988 indicated the population "appeared to be westslope cutthroat." Westslope cutthroat from Doctor Lake could be used to repopulate Lick, Koessler and George lakes. The Doctor Lake fish would be best suited for this due to their demonstrated ability to reside in a high altitude lake for most of their life cycle. Similarly, fish from Big Salmon Lake could be used to repopulate Lena, Necklace and/or Woodward lakes. This could be accomplished by trapping a portion of the populations using Fyke nets, holding fish in a cage while disease and genetic tests are being performed, then transporting them to the destination sites. A final option for sources would be to capture and propagate genetically pure fish from any one of the many streams on the east shore of Hungry Horse Reservoir.

The following excerpts are from Leary et al. (no date) and provide some historical information about the development of westslope cutthroat brood stocks in Montana:

The first attempt by MFWP to establish a westslope cutthroat trout brood stock occurred in 1952. In January, Bob Mitchell, Ed Furnish, and a Great Falls-area game warden flew into the Big Prairie Ranger Station in the Bob Marshall Wilderness. They captured 32 fish by hook and line from Big Salmon Lake in about 4 to 5 days. The fish were temporarily held in a live box, subsequently, anaesthetized, packed in moss-lined boxes, and flown to the Jocko River State Trout Hatchery. Only a small number of eggs were obtained from these fish in the spring of 1953 and 1954. In May of 1955, the fish from these two egg takes were transferred to the Hamilton hatchery where a brood stock was maintained until the hatchery closed in 1961. The broad stock was then transferred to the Libby hatchery.

It is believed that the fish obtained from Big Salmon Lake to establish the brood stock were slightly hybridized with rainbow trout when obtained in 1952. In 1964, an attempt to collect additional fish for the brood stock from Big Salmon Lake was stopped when "good looking" rainbow trout were captured. Furthermore, North Bigelow Lake was barren until it was stocked with fish from the brood stock in 1961. This was the only time the lake was stocked and electrophoretic analysis of 25 fish collected 5 September, 1984 indicated the population was a westslope cutthroat-rainbow trout hybrid swarm with a 3% rainbow trout genetic contribution.

The second attempt to establish a westslope cutthroat trout brood stock occurred in 1954. In June, personnel from the United States Fish and Wildlife Service, MFWP, and Kalispell sportsmen caught about 135 adult fish from several Hungry Horse Reservoir tributaries including Felix, Hungry Horse, Murray, Quintonkon, and Sullivan creeks. The fish were taken to the Creston National Fish Hatchery where they were successfully spawned in late June. In 1955 and 1956, however, males and females ripened at different times so milt from Yellowstone cutthroat trout maintained at the hatchery was often used to fertilize the eggs. This brood stock and production fish were transferred to the Anaconda hatchery in the spring of 1957 and all fish were subsequently stocked.

Prior to hybridization in the hatchery, the fish used to establish the above brood stock are believed to have been genetically pure westslope cutthroat trout. Electrophoretic analysis of samples obtained from the tributaries in 1983 indicated they all contained pure westslope cutthroat trout.

In 1956, the Somers hatchery obtained fertilized eggs from 2 or 3 pair of westslope cutthroat trout spawned at the Creston National Fish Hatchery. The progeny from these eggs were then stocked into Laurie Lake in 1958 after it had been chemically rehabilitated. The lake was used as a brood lake from 1960 until 1965 when the population had essentially disappeared.

The Creston National Fish Hatchery apparently did not raise westslope cutthroat trout between 1957 and 1964. In 1964, however, fish from Laurie Lake were transferred to the hatchery and a brood stock was maintained until 1971 when it had to be destroyed for furunculosis disinfection.

When fish from the Hamilton hatchery were transferred to Libby they were mixed with individuals derived from Laurie Lake. These fish were used to establish a brood stock which was maintained at the hatchery until 1969 when all fish were stocked and the hatchery was closed.

Laurie Lake fish were also used to establish another brood stock. In 1965, fish were transferred to Spoon Lake and eggs obtained from the lake were used in the hatchery program through 1970.

In 1965, MFWP again attempted to establish a hatchery westslope cutthroat brood stock. Each year fertilized eggs from 15 pair of fish collected from Emery Creek and Hungry Horse Creek were transferred to the Jocko River State Trout Hatchery. Progeny from these fish were first successfully spawned in 1968. By the early 1970s the brood stock was large enough to be capable of producing over one million eggs for production fish.

In 1977, evidence that the brood stock had undesirable genetic attributes began to accumulate. Compared to fish in Hungry Horse Creek, the brood stock was significantly less variable (Allendorf and Phelps 1980). Furthermore, genetic differences were observed among the 1971 through 1976 year classes indicating a continual loss of genetic variation. This loss of genetic variation was believed to result from practices in the hatchery. Selection was usually for larger fish and spawning time as future brood fish were retained from only a small portion of the spawning season. This selection would directly alter the genetic characteristics of the population at the genes influencing the targeted traits. It would also induce genetic changes at other genes because the small number of individuals used to perpetuate the brood stock would increase the rate of genetic drift.

By 1983, there was good evidence that the loss of genetic variation was adversely affecting the fish. Hatching success was low and developmental problems revealed by morphological deformities and right-left differences of meristic counts on individuals were prevalent (Leary et al. 1985b). Because of these problems it was decided that efforts to maintain the brood stock would be terminated and in 1986 all fish were stocked.

In 1983 MFWP consulted with the University of Montana Wild Trout and Salmon Genetics Lab to develop, from the wild, a brood stock of genetically pure westslope cutthroat trout that would serve conservation needs for the State of Montana. The recommendation from the geneticists was to provide a pure, yet genetically diverse stock of cutthroat that could adapt to multiple situations they were put into. The plasticity of this stock would allow it to be used in rivers, streams, and lakes. The parental stock included 4,600 genetically pure westslope cutthroat trout collected from 12 streams in the South Fork Flathead and 2 tributary streams to the Clark Fork River. Once acclimated to the hatchery, the first spawn from these fish occurred in June 1985. The progeny were first stocked back to the wild in the autumn of 1985 (Mark Sweeney, MFWP, personal communication, 2002). This stock came to be known as the M012 cutthroat (for the species identification number assigned to it by MFWP). Production of the M012 cutthroat allows ample fish for stocking in lakes in the South Fork Flathead in an effort to maintain angling quality for public use. From 1985 through 2002, over 1,000,000 cutthroat trout have been stocked in lakes of the South Fork Flathead drainage. The lakes and streams listed in this proposal have been influenced by genetically pure westslope cutthroat trout from the M012 stock since 1986. This stock of fish was developed specifically for westslope cutthroat trout conservation in the South Fork Flathead drainage and it provides cutthroat for fisheries across the state. The history of this stock suggests it may be perfectly suited to continue serving the needs of the South Fork Flathead cutthroat conservation project. The continued genetic testing of the M012 brood stock confirms that it's genetic variability remains high and that it has no introgression (Shepard 2002). MFWP biologists agree that the M012 brood stock is probably the most extensively tested stock of fish in the state.

Finally, in a letter to Montana Trout Unlimited, the Montana Cutthroat Trout Technical Committee chairperson Brad Shepard succinctly described the perceptions and research results surrounding the theory of genetic diversity among populations (Shepard 2002). In summary, he wrote:

> *…the M012 brood stock 1). was derived primarily from South Fork Flathead River donors, 2) currently has no evidence of introgression, and 3) currently has an acceptably high level of genetic variability. These attributes indicate to us that this brood has met the draft recommendation of the American Fisheries Society that urges incorporation of genetic theory into management programs and for management programs to be compatible with biodiversity of aquatic natural resources…*

Based on this information MFWP has concluded that cutthroat conservation in the South Fork Flathead can best be accomplished by removing hybrid trout and replacing them with genetically pure westslope cutthroat trout. This point was made by U of M geneticists in a May 2002 letter to the Montana Cutthroat Technical Committee (Leary 2002). Given the logistical difficulties of creating drainage specific stocks of fish, the presence of exotic trout downstream of all of the lakes, and the long-term maintenance needs of some lakes, this strategy may be difficult if not precluded. Rather, the two most feasible options are to restore the fisheries in the lakes using M012 cutthroat, or using a combination of M012 and live fish from a donor population. Once each lake is restored with a genetically pure population, the year five post treatment analysis would help determine which of them would require maintenance stocking based on the success of natural reproduction of each lake. After that point genetically pure westslope cutthroat trout from an adjacent population could be infused into the lake population to perpetuate local adaptations. For ease in capture, propagation, and ease of genetic testing, any one of the many streams on the east shore of Hungry Horse Reservoir could provide pure fish for this type of program.

Lake descriptions and management

This section describes the 21 lakes proposed for treatment over a period of approximately 10 years.

Wildcat Lake is a 40-acre lake located in the Jewel Basin Hiking Area at 5,810 feet above sea level and forms the headwaters of Wildcat Creek. The lake has a maximum depth of 112 feet and a total volume of 2,066 acre-feet (Figure B1). The two main surface water inputs to the lake include one perennial stream in the southeast corner and another ephemeral stream in the southwest corner of the lake. The steep gradient of both streams precludes them from harboring a viable population of fish. Fish have been observed spawning at the outlet of the lake on small angular rock. Wildcat Creek flows out of the lake for approximately 35 feet where it flows over a 25-foot waterfall. The stream flows for another 0.09 mile where it enters a small in-stream pond located on a bench below Wildcat Lake. The stream flows for another 3.37 miles where it encounters another barrier waterfall. Total distance from this waterfall to Wildcat Lake is 3.46 miles. Wildcat Creek continues for 0.02 mile to its confluence with Wounded Buck Creek.

Access to Wildcat Creek is made by a 4.3-mile long trail network that starts at the Camp Misery trailhead. U of M genetics lab tests indicate the lake harbors a population of hybrid westslope cutthroat X Yellowstone cutthroat trout. MFWP records indicate the lake was stocked six times from 1938 through 1965 with generic cutthroat trout. From 1975 through 1992 it was stocked eight times with pure westslope cutthroat trout. A survey conducted in 2001 did not detect any amphibians (Maxell 2002).

Wildcat Creek flows out of Wildcat Lake. Three genetic samples have been taken from the creek between 1984 and 1996. The first two indicated the population in the creek was hybridized and a third indicated the creek population was pure westslope cutthroat.

The management objective for this lake is to remove the hybrid trout from it, and from the unnamed pond directly downstream. To achieve this objective, antimycin would be used because it naturally detoxifies in a stream with every 200 feet of downstream elevation drop making containment easier. The elevation differential between Wildcat Lake and the waterfall near the mouth of Wildcat Creek is approximately 1,770 feet, which would detoxify the stream approximately 7 times more than is necessary. Some fish in the stream below the lakes will be killed during the detoxification process. As a safeguard measure, caged fish would be placed in Wildcat Creek near the intersection of forest roads 5339 and 5340, and in Wounded Buck Creek to to monitor the toxicity of water to fish and determine if supplemental detoxification measures should be implemented. If natural detoxification was not sufficient potassium permanganate would be administered at the rate of 1ppm to detoxify the antimycin.

Wildcat Lake will require 404 units (1,515 pounds) of antimycin, administered at 7-8 ppb, to remove the fish from it. This would be transported to the lake by helicopter in 2 loads. Two flights will be required to transport rafts, motors, sprayers and drip stations. Six people will be needed to treat the lake and two additional personnel for the small pond downstream. This will require three flights to transport. Before the treatment begins, monitors will set up a fish cages on Wildcat Creek, and in Wounded Buck Creek just downstream from the Wildcat/Wounded Buck confluence to evaluate detoxification. The monitor at these sites will have a potassium permanganate detoxification station ready to administer at 1 ppm if caged fish show signs of distress. After the treatment, six people will be flown out with most of the equipment. Two people will stay at the lakes to monitor the treatment. The following day, dead fish will be collected from the shoreline of the lake and the small pond downstream, taken to deeper water and sunk. Thereafter the remaining equipment (drip station, sprayers, raft and motor) will be removed. Caged fish stations will be monitored for 48 hours, and then removed.

In August 2002, the outflow stream of Wildcat Lake was gauged and measured to be 2.12 cfs. In September 2002, Wildcat Creek was gauged at its mouth and measured to be 8.2 cfs. At the same time Wounded Buck Creek was gauged above its confluence with Wildcat Creek and found to be 14.4 cfs. Based on this finding antimycin treated water leaving Wildcat Lake would be diluted to a concentration of 0.75 ppb shortly after entering Wounded Buck Creek. This represents a reduction in concentration by approximately 87%. Up to date flow measurements will be used to determine if supplemental detoxification measures are necessary.

MFWP angler use statistics from 1989 through 2001 indicate Wildcat Lake receives and estimated 112 angler days per year (Table 12). Based on this, the lake would be restocked with genetically pure westslope cutthroat trout from the Washoe Park State Fish Hatchery to maintain the fishery. Stocking would occur the July following the treatment and continue for two more years. Beginning in July following the treatment 3,900 fish, of which 700 would be of catchable size, would be stocked in each of the first two years to restore the fishery as quickly as possible. The population would be evaluated on year five post treatment to determine population viability and determine future stocking needs. There is no risk of reinvasion of Wildcat Lake and the pond by downstream fish due to the high gradient stream, and numerous waterfalls that prevent fish from moving upstream.

Clayton Lake is a 62-acre lake located in the Jewel Basin Hiking Area at 6,040 feet above sea level and forms the headwaters of Clayton Creek. The lake has a maximum depth of 193 feet and a volume of 6,948 acre-feet (Figure B2). Small ephemeral streams and spring seeps provide most of the surface water inflow to Clayton Lake, mostly from the south and west shores. Clayton Creek flows out of the lake for 4.52 miles before reaching a barrier falls. The stream continues for 0.03 mile before entering Hungry Horse Reservoir. There are three unnamed tributaries that enter Clayton Creek between the lake and the mouth. The waterfall is believed to be complete barrier to fish that try to enter Clayton Creek from the reservoir. Bull trout have never been documented in Clayton Creek above the falls. Total distance from this fish barrier to Clayton Lake is 4.52 miles.

Access to Clayton Lake is made by a 2.3 mile trail starting at Forest Road 1633 in the Clayton Creek drainage. U of M genetics lab tests indicate the lake harbors a population of hybrid westslope cutthroat X Yellowstone cutthroat trout. MFWP records indicate the lake was stocked six times from 1926 through 1953 with generic cutthroat trout. In 1928 the lake was stocked with rainbow trout. From 1982 through 2001 it was stocked ten times with pure westslope cutthroat trout. An amphibian survey conducted in 2001 detected long toed salamanders and Columbia spotted frogs (Maxell 2002). These two species were observed at two sites 0.38 and 0.6 mile to the northeast.

Clayton Creek flows out of Clayton Lake. The stream has been genetically tested three times and found to contain hybrid westslope X Yellowstone and/or rainbow trout. The most recent sample indicated the population was a hybrid swarm, which means each fish is hybridized.

The management objective for this lake is to remove the hybrid trout from the lake and from the 4.52 miles of stream between the lake and the barrier waterfall. To achieve this objective, Prenfish would be applied to the lake at the prescribed rate of 1 ppm. Water leaving the lake would be allowed to flow downstream in an effort to remove as many hybrid trout from downstream as possible. We would rely on fresh water input from four unnamed tributaries to Clayton Creek to dilute the water and also detoxify using potassium permanganate. Detoxification stations could be installed off road 1633 and/or at road 895 crossing. Furthermore, water entering Hungry Horse Reservoir would be expected to be immediately diluted even further reducing the risk of exposure to bull trout. Up-to-date flow measurements and on-site bioassays would determine if detoxification measures beyond this point are necessary. A potassium permanganate detoxification station would be set up and ready to implement if necessary. Caged fish would be placed in Clayton Creek at road 1633 crossing, at road 895, and in Clayton Creek Bay of Hungry Horse Reservoir to monitor the toxicity of water and determine if supplemental detoxification measures should be implemented.

In September 2002, the outflow stream of Clayton Lake was gauged and measured to be 0.06 cfs and Clayton Creek was gauged at road 895 crossing and measured to be 3.9 cfs. Based on these measurements the Prenfish concentration in Clayton Creek would be 0.02 ppm. This represents a 98% reduction in concentration.

Clayton Lake will require 2,316 gallons (22,697 pounds) of Prenfish, administered at 1 ppm, to remove the fish from it. In liquid form this amounts to 77 30-gallon drums. Because there is not adequate storage space at the lake for this amount of material, and the amount of time it would require a helicopter to transport full barrels in and empty barrels out, SEAT aircraft will be used to transport and apply two thousand gallons (19,600 pounds) of Prenfish in four trips. The remaining 316 gallons (3,097 pounds) would be transported by helicopter in 4 loads. Two flights will be required to transport a raft, motor, sprayers and drip stations. Six people will be needed to treat the lake and will require two flights to transport. Before the treatment begins, monitors will set up fish cages on Clayton Creek at the above mentioned locations to evaluate detoxification. The monitor will have a potassium permanganate detoxification station ready to administer at 1 ppm if caged fish show signs of distress. A helicopter will transport equipment and materials the day before the treatment. The following morning personnel will be transported to the site and prepare for application by boat. Two people would prepare for treating freshwater inputs and seeps using sprayers and drip stations.

In August 2002, Clayton Lake was surveyed by air with SEAT pilot Andy Taylor of Taylor Aviation of Fort Benton, Montana and a project fisheries biologist. In November, 2002, the lake was surveyed by helicopter once again and confirmed that SEAT will be able to perform this application. An application plan using SEAT was developed based on terrain features of the site. The dimensions of Clayton Lake are approximately 2,952 feet long by 1,301 feet wide. Before dispensing, the SEAT would conduct two flyovers to confirm communication with ground personnel at the lake and to test weather conditions. If communication and application variables were appropriate, the plane would begin administering the first load to the lake. The SEAT will approach the lake from the southeast, dispense its load, and exit the lake to the northwest down Clayton Creek drainage. The SEAT will continue down Clayton Creek drainage, circle back and cross over Pioneer Ridge, and approach from the southeast to continue the dispensing. When complete, the SEAT will return to Glacier Airport for refilling. Based on drop experiments conducted in Fort Benton by Taylor Aviation and MFWP, the maximum area of coverage from a single SEAT application of 250 gallons or less is 310 feet long by 88 feet wide. The fact that Prenfish appears milky white when it contacts water will allow the SEAT pilot to see precisely where the previous load was dropped and may place subsequent loads adjacent to them to provide better application coverage. After the first SEAT load is administered, the raft would begin mixing the Prenfish, pumping it to deeper zones of the lake, and the treatment of freshwater inputs would begin. The second SEAT load would return 30 minutes later, conduct the two flyovers to establish communication with the ground, then apply. The raft and all personnel would be removed from the lake each time to wait on the shoreline for the next drop. The third SEAT drop would occur 30 minutes later, and the fourth drop 30 minutes after that. After the fourth drop, the treatment with the raft would resume until finished. When finished, four people will be flown out with most of the equipment. Two people will stay at the site and monitor the treatment. The following day, dead fish will be collected from the shoreline, taken to deeper water and sunk. Thereafter the remaining equipment (drip station, sprayers, raft and motor) and personnel will be removed.

MFWP angler use statistics from 1989 through 2001 indicate Clayton Lake receives an estimated 245 angler days per year (Table 12). Based on this, the lake would be restocked with genetically pure westslope cutthroat trout from the Washoe Park State Fish Hatchery to maintain the fishery. Beginning in July following the treatment 5,800 fish, of which 1000 would be of catchable size, would be stocked in each of the first two years to restore the fishery as quickly as possible. The population would be evaluated on year five post treatment to determine population viability and future stocking needs. There is little risk of reinvasion by downstream fish due to the high gradient stream and the fact that fish in the stream below the lake will be removed down to the barrier during the treatment.

<u>Blackfoot Lake</u> is a 16.5-acre lake located in the Jewel Basin Hiking Area at 5,520 feet above sea level and is in the headwaters of Graves Creek. The lake has a maximum depth of 22 feet and a volume of 205 acre-feet (Figure B3). The outflow stream of Blackfoot Lake is a headwater tributary that forms Graves Creek. From the lake it flows for 0.83 miles where it reaches the other tributary that forms Graves Creek (Black Lake outflow stream). Graves Creek flows for 1.47 miles to the confluence of Cliff Lake Creek, then for 1.43 miles to Seven Acres Creek, then for 2.03 miles before entering Handkerchief Lake. After leaving Handkerchief Lake, Graves Creek flows for 0.54 mile to the confluence of Aeneas Creek, then for 0.79 mile to the barrier waterfall near its mouth. This barrier waterfall blocks all upstream fish passage. Total distance from Blackfoot Lake to the Graves Creek fish barrier, including the length of Handkerchief Lake, is 7.72 miles.

A 5.2-mile long trail network starting at the Camp Misery trailhead accesses Blackfoot Lake. University of Montana genetics lab tests indicate the lake harbors a population of hybrid westslope cutthroat X rainbow trout. MFWP records indicate Blackfoot Lake was stocked with generic cutthroat trout in 1938 and in 1965. From 1982 through 2000 it was stocked ten times with genetically pure westslope cutthroat trout. The source of rainbow trout genes in the lake is unknown. A genetic sample taken in 2001 indicates the population is approximately 66% westslope and 34% rainbow. Amphibian surveys conducted in 2001 indicated long toed salamanders and Columbia spotted frogs were present at the lake (Maxell 2002).

Water leaving Blackfoot Lake forms Graves Creek. From 1983 to 1999, five separate genetic tests were conducted on the Graves Creek trout population and all were various hybridized combinations of westslope cutthroat, Yellowstone cutthroat and/or rainbow trout.

The management objective for this lake is to remove the hybrid trout from it and from the 5.76 miles of stream that flows out of Blackfoot Lake to the inlet of Handkerchief Lake. To achieve this objective, Prenfish would be applied to the lake at the prescribed rate of 1 ppm. Water leaving the lake would be allowed to flow downstream in an effort to remove as many hybrid trout from downstream as possible. The downstream boundary for this treatment is Handkerchief Lake. We would rely on fresh water input from the streams leaving Black Lake, Cliff Lake and Seven Acres lakes to dilute the water leaving Blackfoot Lake. Up-to-date flow measurements and on-site bioassays would determine if detoxification measures beyond this point are necessary. Caged live fish would be set in Graves Creek upstream of Handkerchief Lake to measure the toxicity of water. As an added safeguard measure, we would rely on Handkerchief Lake to further dilute this stream, and a detoxification station would be set up and ready to implement if necessary.

In September 2002, water leaving Blackfoot Lake was gauged at the lake outlet and measured to be 0.42 cfs, and Graves Creek was measured upstream of Handkerchief Lake at 3.3 cfs. Based on these measurements, the concentration of Prenfish in Graves Creek above Handkerchief Lake would be 0.12 ppm. This represents an 88% reduction in concentration. Furthermore, the 811 acre feet of water in Handkerchief Lake would further dilute the 0.12 ppm Prenfish to sub-lethal levels. In September 2002, discharge from Jones and Aeneas Creek were measured at 8.9 cfs, and Graves Creek downstream of Handkerchief Lake was measured at 7.2 cfs. Based on these calculations, any Prenfish treated water leaving Handkerchief Lake would be further diluted by these freshwater inputs.

Blackfoot Lake will require 68 gallons (667 pounds) of Prenfish, administered at 1 ppm, to remove the fish from it. This would be transported to the lake by helicopter in 1 load. Two flights will be required to transport a raft, motor, sprayers and drip stations. Four people will be needed to treat the lake and will require two flights to transport. Before the treatment begins, monitors will set up fish cages on Graves Creek just above and below Handkerchief Lake to evaluate detoxification. The monitor above Handkerchief Lake will have a potassium permanganate detoxification station ready to administer if caged fish show signs of distress. After the treatment, two people will be flown out with most of the equipment. Two people will stay at the site and monitor the treatment. The following day, dead fish will be collected from the shoreline, taken to deeper water and sunk. Thereafter the remaining equipment (drip station, sprayers, raft and motor) will be removed. Caged fish stations will be monitored for 48 hours, then removed.

MFWP angler use statistics from 1989 through 2001 indicate Blackfoot Lake receives an average 332 angler days per year (Table 12). Based on this, the lake would be restocked with genetically pure westslope cutthroat trout from the Washoe Park State Fish Hatchery to maintain the fishery. Beginning in July following the treatment 1,600 fish would be stocked each year for three years. The population would be evaluated on year five post treatment to determine population viability and future stocking needs. There is little risk of reinvasion by downstream fish due to the high gradient of the stream below the lake, and the fact that downstream fish would be removed during the treatment.

<u>Black Lake</u> is a 49.1-acre lake located in the Jewel Basin Hiking Area at 6,045 feet above sea level in the headwaters of Graves Creek. The lake has a maximum depth of 157 feet and a volume of 4,493 acre-feet (Figure B4). The outflow stream of Black Lake is a headwater tributary of Graves Creek and flows for 0.23 mile where it reaches an unnamed pond. From this pond, the stream flows for 0.93 mile where it reaches the other tributary of Graves Creek (Blackfoot Lake outflow stream). Graves Creek flows for 1.47 miles to the confluence of Cliff Lake Creek, then for 1.43 mile to Seven Acres Creek, then for 2.03 miles before entering Handkerchief Lake. After leaving Handkerchief Lake, Graves Creek flows for 0.54 mile to the confluence of

Aeneas Creek, then for 0.79 mile to the barrier waterfall near its mouth. This barrier waterfall blocks all upstream fish passage. Total distance from Black Lake to the Graves Creek fish barrier, including the length of Handkerchief Lake, is 8.05 miles.

A 2.5-mile long trail network beginning at the Camp Misery trailhead accesses Black Lake. U of M genetics lab tests indicate the lake harbors a population of various hybrid combinations of westslope cutthroat, Yellowstone cutthroat and rainbow trout. MFWP records indicate Black Lake was stocked four times with generic cutthroat trout from 1938 to 1973. From 1979 through 1999 it was stocked ten times with pure westslope cutthroat trout. A genetic sample taken in 2001 indicates the lake population contains westslope X Yellowstone hybrids and westslope X rainbow hybrids. The source of rainbow trout genes in the lake is unknown. Amphibian surveys conducted in 1999 (USFS) and 2001 (Maxell) did not detect any amphibians at Black Lake. Long toed salamanders, tailed frogs, and Columbia spotted frogs were detected among six neighboring lakes within a 0.6 mile radius of Black lake (Maxell 2002). They are: three of the Jewel Lakes located 0.46 mile to the north, one unnamed water body 0.63 mile to the northeast and the Picnic lakes located 0.33 mile to the west.

Water leaving Black Lake forms Graves Creek. From 1983 to 1999 five separate genetic tests were conducted on the Graves Creek trout population and all were various combinations of hybridized westslope cutthroat, Yellowstone cutthroat and/or rainbow trout.

The management objective for this lake is to remove the hybrid trout from it and from the 6.09 miles of stream between Black Lake and Handkerchief Lake. To achieve this objective, Prenfish would be applied to the lake at the prescribed concentration of 1 ppm. Water leaving the lake would be allowed to flow downstream in an effort to remove the trout from downstream. We would rely on fresh water input from the Blackfoot Lake, Cliff Lake and Seven Acres lakes effluents to dilute the water leaving Black Lake. Up-to-date flow measurements and on-site bioassays would determine if detoxification measures beyond this point are necessary. Caged live fish would be set in Graves Creek upstream of Handkerchief Lake to measure the toxicity of water. As an added safeguard measure, we would rely on Handkerchief Lake to further dilute treated water, and a detoxification station would be set up and ready to implement if necessary.

In August 2002, water leaving Black Lake was gauged at the lake outlet and measured to be 1.27 cfs. Twenty days later Graves Creek was gauged upstream of Handkerchief Lake at 3.3 cfs. Based on these measurements the Prenfish concentration in Graves Creek, upstream of Handkerchief Lake, would be 0.38 ppm. This represents a 62% reduction in concentration. Furthermore, the 811 acre-feet of water in Handkerchief Lake would dilute the stream water to sub-lethal levels. In September 2002, discharge from Jones and Aeneas Creek were measured at 8.9 cfs, and Graves Creek downstream of Handkerchief Lake was measured at 7.2 cfs. Any Prenfish treated water leaving Handkerchief Lake would be further diluted by these freshwater inputs.

Black Lake will require 1,469 gallons (14,396 pounds) of Prenfish, administered at 1 ppm, to remove the fish from it. One thousand gallons (9,800 pounds) of Prenfish would be transported to the lake in two trips by SEAT aircraft and the remaining 469 gallons (4,596 pounds) would be transported by helicopter in 6 loads. Two flights will be required to transport a raft, motor, sprayers and drip stations. Five people will be needed to treat the lake and will require two flights to transport. Before the treatment begins, monitors will set up fish cages on Graves Creek just above and below Handkerchief Lake to evaluate detoxification. The monitor below Handkerchief Lake will have a potassium permanganate detoxification station ready to administer if caged fish show signs of distress. A helicopter will begin to transport personnel, equipment and materials first thing in the morning and get set up for application by boat. Two people would prepare for treating freshwater inputs and seeps using sprayers and drip stations.

In August 2002, Black Lake was surveyed by air with SEAT pilot Andy Taylor of Taylor Aviation in Fort Benton, Montana, and a project fisheries biologist. The pilot indicated that the layout of Black Lake allows for four drops of 250 gallons of Prenfish each. An application plan using SEAT was developed based on terrain features of the site. The dimensions of Black Lake are approximately 2,297 feet long by 1,286 feet wide. Before dispensing, the SEAT would conduct two flyovers to confirm communication with ground personnel at the lake and to test weather conditions. If communication and application variables are appropriate, the SEAT will begin administering its load. Mach flyovers conducted in November 2002 with a Hughes 500 helicopter revealed that the best approach to Black Lake would be from the southwest corner, the plane would make its descent toward the lake, make a slight bank to the east, dispense it's load and continue northeast down Graves Creek drainage. The SEAT will continue down Graves Creek drainage, circle back and continue the dispensing. Based on drop experiments conducted in Fort Benton by Taylor Aviation and MFWP, the maximum area of coverage from a single SEAT application of 250 gallons or less is 310 feet long by 88 feet wide. The fact that Prenfish appears milky white when it contacts water will allow the SEAT pilot to see precisely where the previous load was dropped and may place subsequent loads adjacent to them to provide better application coverage. After dispensing its load the SEAT will return to Glacier Airport for refilling. After the first load is completely applied, the raft would begin mixing the Prenfish at the surface and begin to administer at deeper depths, and treatment of freshwater inputs would begin. Upon returning with a second load, the SEAT pilot would conduct flyovers to establish communication with the ground and test weather conditions. The raft and all personnel would be removed from the lake and wait on the shoreline for the second drop. After the second drop, the treatment with the raft would resume until finished. After the treatment, three people will be flown out with most of the equipment. Two people will stay at the site and monitor the treatment. The following day, dead fish will be collected from the shoreline, taken to deeper water and sunk. Thereafter the remaining equipment (drip station, sprayers, raft and motor) and personnel will be removed.

MFWP angler use statistics from 1989 through 2001 indicate Black Lake receives an estimated 107 angler days per year (Table 12). Based on this, the lake would be restocked with genetically pure westslope cutthroat trout from the Washoe Park State Fish Hatchery to maintain the fishery. Beginning in July following the treatment 4,900 fish would be stocked each year for three years. The population would be evaluated on year five post treatment to determine population viability and future stocking needs. There is little risk of reinvasion by downstream fish due to the high gradient of the stream below the lake and the fact that fish below the lake will be removed during the treatment. The risk of reinvasion of Black Lake by downstream fish is low due to the high gradient stream and the fact that downstream fish will be removed during the treatment.

Handkerchief Lake is a 51.3-acre lake located on the Flathead National Forest at 3,835 feet above sea level near the mouth of the Graves Creek drainage. The lake has a maximum depth of 24 feet and a total volume of 811.5 acre-feet (Figure B5). Graves Creek is the only known stream that flows into the lake. Graves Creek flows out of Handkerchief Lake for 0.54 mile before it joins with Aeneas Creek, then flows for another 0.79 mile before reaching the waterfall fish barrier just above Hungry Horse Reservoir. This barrier prevents all fish from moving upstream into Graves Creek from Hungry Horse Reservoir. Distance from this fish barrier to the lake is 1.33 miles.

Access to Handkerchief Lake is made by a road off Forest Road 895. U of M genetics lab tests indicate the lake harbors a population of tri-brid westslope cutthroat X Yellowstone X rainbow trout. The most recent sample collected in 2000 revealed the population is a hybrid swarm which means each fish has genes from all three species. MFWP records indicate the lake was stocked seven times from 1936 through 1957 with generic cutthroat trout. From 1986 through 2001 it was stocked eight times with pure westslope cutthroat trout. Amphibian surveys conducted in 2001 detected Columbia spotted frogs. Tailed frogs were detected in a small basin approximately 0.36 mile southeast of the lake, and garter snakes were detected 0.61 mile to the southeast near Hungry Horse Reservoir (Maxell 2002).

Graves Creek is the only inflow to Handkerchief Lake. Hybrid fish from Blackfoot and Black lakes are the major source of hybrid fish in Handkerchief Lake. From 1983 to 1999 five separate genetic tests were conducted on the Graves Creek trout population and all were various hybridized combinations of westslope cutthroat, Yellowstone cutthroat and/or rainbow trout.

The management objective for this lake is to remove the hybrid trout from it, and from the 1.33 miles of stream between the lake and Hungry Horse Reservoir. It will be necessary to treat a small segment of Graves Creek upstream of the lake to remove any hybrid fish that may have recolonized between the treatments of Black and Blackfoot lakes. To achieve this objective, antimycin would be applied to approximately 1 mile of

Graves Creek upstream of Handkerchief Lake. Antimycin would then be applied to the lake at the prescribed rate of 7-8 ppb. The elevation differential between Handkerchief Lake and Hungry Horse Reservoir is approximately 275 feet. The ability of antimycin to detoxify with every 200 feet of stream elevation drop makes this the safest method to remove hybrid trout from the lake and stream while safeguarding the bull trout that may be residing in Graves Creek Bay of Hungry Horse Reservoir. All trout populations in the Graves Creek drainage have been identified as a threat to the genetically pure fish in Hungry Horse Reservoir.

There are three detoxification measures that will be used during the treatment of Handkerchief Lake. Caged fish placed in Graves Creek near the mouth would allow us to monitor the toxicity of water to fish. First, elevation calculations indicate that antimycin will be detoxified before it reaches Hungry Horse Reservoir. To measure this, the caged fish will be placed at three intervals in Graves Creek downstream of the lake; one at the lake outlet, one at the mouth of the creek, and one at an intermediate location between the two. Second, dilution by freshwater would also be used to aid in the detoxification. In September 2002, Graves Creek above Handkerchief Lake was gauged and measured at 3.3 cfs, and below the lake it was measured at 7.2 cfs. In September 2002, discharge from Jones and Aeneas creeks was measured at 8.9 cfs, and Graves Creek downstream of Handkerchief Lake was measured at 7.2 cfs. Any antimycin treated water leaving Handkerchief Lake would be diluted by these freshwater inputs by nearly 61%. Finally, a detoxification station would be set up and ready to implement if caged fish are showing signs of distress. This would safeguard any bull trout in the Graves Creek Bay of Hungry Horse Reservoir. On-site bioassays and current flow measurements will be used to determine the level of natural detoxification available at the time of treatment.

Handkerchief Lake will require 159 units (596 pounds) of antimycin, administered at 7-8 ppb, to remove the fish from it. This would be transported to the lake by truck. All equipment will be transported by truck. Five people will be needed to treat the lake. Before the treatment begins, monitors will set up a fish cage on Graves Creek at three locations downstream of the lake. After the treatment, two people will stay at the site and monitor the treatment. The following day, dead fish will be collected from the shoreline, taken to deeper water and sunk. Thereafter the remaining equipment will be removed. The caged fish station will be monitored for 48 hours, then removed.

MFWP angler use statistics from 1989 through 2001 indicate Handkerchief Lake receives an estimated 702 angler days per year (Table 12). Based on this, the lake would be restocked with genetically pure westslope cutthroat trout from the Washoe Park State Fish Hatchery. Stocking would begin in June and July following the treatment and continue annually as needed to maintain the fishery. Multiple year classes of cutthroat trout, including catchable sizes, would be stocked in the lake to restore the fishery as quickly as possible. MFWP records indicate that a total of 711,000 grayling have been stocked over 14 separate occasions between 1954 and 1998 in Handkerchief Lake. Despite this, grayling rarely occur in Hungry Horse Reservoir gill net surveys and appear to be relatively inert in the fish community. Arctic grayling do not hybridize with or appear to compete for resources with any other game fish in the South Fork Flathead drainage. Semi-annual snorkel surveys on the South Fork Flathead River have failed to observe grayling in the river. Restocking arctic grayling in Handkerchief Lake may occur, and will be determined closer to the treatment of the lake. Although the stream reach below Handkerchief Lake has not been thoroughly surveyed by ground to identify additional fish barriers, the risk of reinvasion of Handkerchief Lake by downstream fish will be reduced by the fact that the source fish from adjacent tributaries will be removed during the treatment of the lakes in their headwaters.

Upper Three Eagles Lake is a 10.8-acre lake located in the Jewel Basin Hiking Area at 6,340 feet above sea level and is in a headwater tributary basin of Aeneas Creek. The lake has a maximum depth of 72 feet and has a volume of 487 acre-feet (Figure B6). The outlet stream flows from the lake for 0.28 mile before entering Lower Three Eagles Lake.

There is no known trail access to Upper Three Eagles Lake. U of M genetics lab tests indicate the lake harbors a population of hybrid westslope X Yellowstone cutthroat trout. MFWP records indicate Upper Three Eagles Lake was stocked once with generic cutthroat trout in 1967. Then, from 1975 through 1993 it was stocked five times with pure westslope cutthroat trout. Amphibian surveys conducted in 2001 did not detect any amphibians. Long toed salamanders and Columbia spotted frogs were detected at three neighboring lakes 0.58 mile to the west of Upper Three Eagles Lake (Maxell 2002).

The management objective for this lake is to remove the hybrid trout population from it and its effluent stream. To achieve this objective, Prenfish would be applied to the lake at the prescribed rate of 1 ppm. Water leaving the lake would be allowed to flow downstream in an effort to remove hybrid trout from the intermediate section of stream between the upper and lower lakes. Given the proximity of the two lakes, treating the lower lake would be mandatory during the treatment of the upper lake.

Upper Three Eagles Lake will require 162 gallons (1,588 pounds) of Prenfish, administered at 1 ppm, to remove the fish from it. This would be transported to the lake by helicopter in 2 loads. Two flights will be required to transport a raft, motor, sprayers and drip stations. Four people will be needed to treat the lake and will require two flights to transport. This lake will be treated simultaneously with Lower Three Eagles lake. After the treatment, two people will be flown out with most of the equipment. Two people will stay at the site and monitor the treatment. The following day, dead fish will be collected from the shoreline, taken to deeper water and sunk. Thereafter the remaining equipment (drip station, sprayers, raft and motor) will be removed.

The lake would be restocked with genetically pure westslope cutthroat trout from the Washoe Park State Fish Hatchery. Beginning in July following the treatment 900 fish would be stocked each year for three years. The population would be evaluated on year five post treatment to determine population viability and to determine future stocking needs. There is little risk of reinvasion by downstream fish into the lake due to the steep gradient of the stream, and the fact that fish will be removed from this section of stream during the treatment.

Lower Three Eagles Lake is a 8.7-acre lake located in the Jewel Basin Hiking Area at 5,705 feet above sea level and is in a headwater tributary basin of Aeneas Creek. The lake has a maximum depth of 84 feet and has a volume of 255 acre-feet (Figure B7). The outlet stream flows from the lake for 1.12 miles before entering Aeneas Creek. Aeneas Creek then flows for 0.73 mile before meeting with Jones Creek, and then continues for 0.38 mile where it meets with Graves Creek. Graves Creek flows for an additional 0.79 mile to the barrier waterfall at its mouth. Aeneas, Jones, and Graves creeks are all isolated from upstream movement by Hungry Horse Reservoir fish by a barrier waterfall at the mouth of Graves Creek. Distance from the Three Eagles Lake complex to the fish barrier at the mouth of Graves Creek is 3.02 miles.

There is no known trail access to Lower Three Eagles Lake. The fish population has never been genetically tested. However, MFWP records indicate Lower Three Eagles Lake was stocked once in 1967 with generic cutthroat trout. Follow-up genetic surveys on other lakes stocked with the generic cutthroat trout have revealed the stock was largely comprised of Yellowstone cutthroat genes. In addition, the populations upstream and downstream have been tested and found to contain hybrid trout. Based on the fact that Lower Three Eagles Lake is surrounded by hybrid trout, it is assumed that fish from the upper lake have entered it, or at least have the opportunity to enter it. It would be difficult, if not impossible, to treat the upper lake and the lower stream without treating Lower Three Eagles Lake. For this reason, Lower Three Eagles Lake will be treated to remove any threat of hybrid trout remaining. From 1975 to 1997 the lake was stocked seven times with pure westslope cutthroat trout. Amphibian surveys conducted in 2001 did not detect any amphibians. Long toed salamanders and Columbia spotted frogs were detected at three neighboring lakes 0.83 mile to the west of Lower Three Eagles Lake (Maxell 2002).

Water leaving Lower Three Eagles Lake flows into Aeneas Creek. Three separate genetic tests conducted on Aeneas Creek from 1983 through 1998 indicate the population is westslope cutthroat hybridized with Yellowstone cutthroat trout and rainbow trout. The 1998 sample revealed that the population was a hybrid swarm, which means each fish sampled had rainbow trout genes in it.

The management objective for this lake is to remove the hybrid trout from the lake and from the 2.23 miles of stream down to the confluence with Graves Creek. To achieve this objective, Prenfish applied during the treatment of the upper lake would be allowed to enter the lower lake. A small amount of Prenfish would be added to the lower lake to account for volumetric differences between the upper and lower lake. Water leaving the lower lake would be allowed to flow downstream in an effort to remove as many hybrid trout from downstream as possible. We would rely on fresh water input from Aeneas, Jones and Graves creeks to dilute the water leaving the Three Eagles lakes complex.

Caged fish would be placed in Jones Creek near its mouth and in Graves Creek near the Aeneas-Graves confluence to monitor the toxicity of water to fish. Potassium permanganate would be on hand to detoxify the Prenfish if caged fish at the Graves Creek site did not survive. This would safeguard any bull trout in the Graves Creek bay of Hungry Horse Reservoir. Up-to-date flow measurements and on-site bioassays would determine if detoxification measures beyond this point are necessary. A potassium permanganate detoxification station would be set up and ready to implement if necessary. In September 2002, water leaving Lower Three Eagles Lake was gauged at 0.15 cfs, Aeneas Creek was gauged at 5.5 cfs, Jones Creek was gauged at 3.4 cfs, and Graves Creek was gauged at 7.2 cfs. Based on these measurements the Prenfish concentration in Aeneas Creek would be 0.02 ppm. This represents a 98% reduction in concentration. In addition, water from Aeneas Creek would be further diluted by water from Graves Creek by approximately 40%.

Lower Three Eagles Lake will require a maximum of 85 gallons (816 pounds) of Prenfish, administered at 1 ppm, to remove the fish from it. The actual amount of Prenfish needed to treat this lake depends largely on the amount of Prenfish treated water flowing into it from Upper Three Eagles Lake. Up to date flow measurements will be used to adjust the actual amount of Prenfish needed to treat the lower lake. Prenfish would be transported to the lake by helicopter in 1 load. Two flights will be required to transport a raft, motor, sprayers and drip stations. Four people will be needed to treat the lake and will require two flights to transport. This lake will be treated simultaneously with Upper Three Eagles Lake. Before the treatment begins, monitors will set up a fish cage in Jones Creek and also in Graves Creek just below the confluence of Aeneas Creek to evaluate detoxification. This site is located approximately 385 feet downstream of forest road 9797 crossing and would be accessed by foot. The monitor at this site will have a potassium permanganate detoxification station ready to administer if caged fish show signs of distress. After the treatment, two people will be flown out with most of the equipment. Two people will stay at the site and monitor the treatment. The following day, dead fish will be collected from the shoreline, taken to deeper water and sunk. Thereafter the remaining equipment (drip station, sprayers, raft and motor) will be removed. Caged fish stations will be monitored for 48 hours, and then removed.

Lower Three Eagles Lake would be restocked with genetically pure westslope cutthroat trout from the Washoe Park State Fish Hatchery. Beginning in July following the treatment 900 fish would be stocked each year for three years. The population would be evaluated on year five post treatment to determine population viability and future stocking needs. The risk of reinvasion form downstream fish into this lake is low due to the high gradient of the stream and the fact that downstream fish would be removed during the treatment.

<u>Pilgrim Lake</u> is a 29.9-acre lake located in the Jewel Basin Hiking Area at 6,365 feet above sea level and is in a headwater tributary basin to Jones Creek. The lake has a maximum depth of 154 feet and has a volume of 2,528 acre-feet (Figure B8). The outlet stream flows from the lake for 0.8 mile before joining with the other headwater fork to Jones Creek (Big Hawk Lake effluent). Jones Creek flows for another 2.09 miles before entering Aeneas Creek. Aeneas Creek flows for 0.38 mile where it meets with Graves Creek. Graves Creek flows for an additional 0.79 mile to the barrier waterfall at its mouth. Aeneas, Jones, and Graves Creeks are all isolated from upstream movement by Hungry Horse Reservoir fish by a barrier waterfall at the mouth of Graves Creek. Distance from Pilgrim Lake to the fish barrier at the mouth of Graves Creek is 4.06 miles. Upper Pilgrim Lake was surveyed in 2001 and found to be fishless.

There is no known trail access to Pilgrim Lake. U of M genetics lab tests indicate the lake harbors a population of hybrid westslope X rainbow trout. MFWP records indicate Pilgrim Lake was stocked three times with westslope cutthroat trout from 1989 through 1994. The source of rainbow trout genes in the lake is unknown. Amphibian surveys conducted in 2001 did not detect any amphibians. Long toed salamanders were detected at Upper Bighawk Lake located 0.69 mile to the south of Pilgrim Lake (Maxell 2002).

Water leaving Pilgrim Lake forms the headwaters to Jones Creek. Three genetic samples conducted on Jones Creek from 1983 through 1989 indicate the population is hybridized westslope cutthroat X Yellowstone cutthroat trout. Jones Creek then flows into Aeneas Creek. Three separate genetic tests conducted on Aeneas

Creek from 1983 through 1998 indicate the population is westslope cutthroat hybridized with Yellowstone cutthroat trout and rainbow trout. The 1998 sample revealed that the population was a hybrid swarm, which means each fish sampled had rainbow trout genes in it.

The management objective for this lake is to remove the hybrid trout from the lake and from the 3.27 miles of stream between the lake and the Aeneas-Graves confluence. To achieve this objective, Prenfish would be applied to the lake at the prescribed rate of 1 ppm. Prenfish-treated water leaving the lake would be allowed to flow downstream in an effort to remove as many hybrid trout from downstream as possible. We would rely on fresh water input from Jones Creek, Aeneas Creek and Graves Creek to dilute the water leaving Pilgrim Lake to sublethal levels before it enters bull trout waters in Hungry Horse Reservoir. Up-to-date flow measurements and on-site bioassays would determine if detoxification measures beyond this point are necessary. Caged fish placed in Jones Creek near its mouth and at Graves Creek near its mouth would allow us to monitor the toxicity of water to fish. Potassium permanganate would be on hand to detoxify the Prenfish if caged fish at the Graves Creek site did not survive. This would safeguard any bull trout in the Graves Creek bay of Hungry Horse Reservoir.

In September 2002, Pilgrim Lake was surveyed and found to have no surface water flowing from it. The outflow channel from Pilgrim Lake was dry to the point of the confluence with the Bighawk Lake outflow stream. Based on this information, Prenfish treated water flowing subterranean would be detoxified through natural binding processes. A Prenfish drip station would be installed at the point where the stream resurfaced, and run for 8 hours to remove fish from that point down to the Aeneas-Graves confluence. If during the treatment of Pilgrim Lake, surface water is flowing from it, water from Bighawk Lake, Aeneas Creek, and Graves Creek would be used to dilute it.

Pilgrim Lake will require 842 gallons (8,252 pounds) of Prenfish, administered at 1 ppm, to remove the fish from it. Five hundred gallons (4,900 pounds) would be transported to the lake in 1 trip by SEAT aircraft and the remaining 342 gallons (3,352 pounds) would be transported by helicopter in 4 loads. Two helicopter flights will be required to transport a raft, motor, sprayers and drip stations. Five people will be needed to treat the lake and will require two helicopter flights to transport. Before the treatment begins, monitors will set up a fish cage on Aeneas Creek downstream of Jones Creek, and another on Graves Creek just below the confluence of Aeneas Creek to evaluate Prenfish effects on fish. The Graves Creek monitor will have a potassium permanganate detoxification station ready to administer if caged fish show signs of distress. All personnel, equipment and materials will be at the site on the morning of the treatment and they will be ready to begin the application by boat. Two people prepare for treating freshwater inputs and seeps using sprayers and drip stations.

In August 2002, Pilgrim Lake was surveyed by air with SEAT pilot Andy Taylor of Taylor Aviation in Fort Benton, Montana, and a project fisheries biologist. The pilot indicated that the layout of Pilgrim Lake allows for four 125 gallon drops of Prenfish. An application plan using SEAT was developed based on terrain features of the site. Pilgrim Lake measures approximately 1,789 feet long by 959 feet wide. Before dispensing, the SEAT would conduct two flyovers to confirm communication with ground personnel at the lake and to test weather conditions. Mach flyovers conducted in November 2002 with a Hughes 500 helicopter revealed that the best approach to Pilgrim Lake would be from the southwest corner. The plane would make its descent toward the lake, make a slight bank to the east, dispense it’s load and continue easterly down Jones Creek drainage. The SEAT will circle back to the south of Bighawk Lake, and approach from the southwest to continue the dispensing. After the final drop, the SEAT would return to the Glacier Airport. Based on drop experiments conducted in Fort Benton by Taylor Aviation and MFWP, the maximum area of coverage from a single SEAT application of 250 gallons or less is 310 feet long by 88 feet wide. The fact that Prenfish appears milky white when it contacts water will allow the SEAT pilot to see precisely where the previous load was dropped and may place subsequent loads adjacent to them to provide better application coverage. Only after the drop, would the raft begin mixing the Prenfish at the surface, begin to administer at deeper depths, and treat freshwater inputs. When finished, three people will be flown out with most of the equipment. Two people will stay at the site and monitor the treatment. The following day, dead fish will be collected from the shoreline, taken to deeper water and sunk. Thereafter the remaining equipment (drip station, sprayers, raft and motor) and personnel will be removed. Caged fish stations will be monitored for 48 hours, and then removed.

MFWP angler use statistics from 1989 through 2001 indicate Pilgrim Lake receives and estimated 34 angler days per year (Table 12). Based on this, the lake would be restocked with genetically pure westslope cutthroat trout from the Washoe Park State Fish Hatchery to maintain the fishery. Beginning in July following the treatment 3,000 fish would be stocked each year for three years. The population would be evaluated on year five post treatment to determine population viability and future stocking needs. The risk of reinvasion by fish from downstream is nonexistent due to a steep rock slab fish barrier, approximately 300 feet long, at the outlet of the lake.

Lower Bighawk Lake is a 27.3-acre lake located in the Jewel Basin Hiking Area at 5,990 feet above sea level and is in a headwater tributary basin to Jones Creek. The lake has a maximum depth of 39 feet and has a volume of 612 acre-feet (Figure B9). The outlet stream flows from the lake for 0.5 mile then joins with the other headwater fork to Jones Creek (Pilgrim Lake effluent). Jones Creek flows for another 2.09 miles before entering Aeneas Creek. Aeneas Creek flows for 0.38 mile where it meets with Graves Creek. Graves Creek flows for an additional 0.79 mile to the barrier waterfall at its mouth. Aeneas, Jones, and Graves Creeks are all isolated from upstream movement by Hungry Horse Reservoir fish by a barrier waterfall at the mouth of Graves Creek. Distance from Lower Bighawk Lake to the fish barrier at the mouth of Graves Creek is 3.76 miles.

Access to Bighawk Lake is gained by a 5.6-mile long trail network that starts at Forest Road 895 in the Wheeler Creek Drainage. U of M genetics lab tests indicate the lake harbors a population of hybridized westslope cutthroat X Yellowstone cutthroat trout. MFWP records indicate the lake was stocked in 1941 with generic cutthroat trout. From 1986 through 1994 the lake was stocked eight times with pure westslope cutthroat trout. Amphibian surveys conducted in 2001 did not detect any amphibians. Long toed salamanders were detected at Upper Bighawk Lake located 0.36 mile to the west and long toed salamanders and Columbia spotted frogs were detected at three unnamed basins located 1.37 miles to the southwest (Maxell 2002).

Water leaving Lower Bighawk Lake forms the headwaters to Jones Creek. Three genetic samples conducted on Jones Creek from 1983 through 1989 indicate the population is hybridized westslope cutthroat X Yellowstone cutthroat trout. Jones Creek then flows into Aeneas Creek. Three separate genetic tests conducted on Aeneas Creek from 1983 through 1998 indicate the population is westslope cutthroat hybridized with Yellowstone cutthroat trout and rainbow trout. The 1998 sample revealed that the population was a hybrid swarm, which means each fish sampled had rainbow trout genes in it.

The management objective for this lake is to remove the hybrid trout from the lake and from the 2.97 miles of stream between the lake and the Graves Creek confluence. Prenfish treated water would be allowed to flow downstream to remove any fish that may have escaped the Pilgrim Lake treatment. To achieve this objective, Prenfish would be applied to the lake at the prescribed rate of 1 ppm. We would rely on fresh water input from Jones Creek, Aeneas Creek and Graves Creek to dilute the water leaving Bighawk Lake to sublethal levels before it enters bull trout waters in Hungry Horse Reservoir. Caged fish would be placed in Jones Creek near its mouth and at Graves Creek below its confluence with Aeneas Creek to monitor the toxicity of water to fish. Up-to-date flow measurements and on-site bioassays would determine if detoxification measures beyond this point are necessary. A potassium permanganate detoxification station would be set up and ready to implement if necessary.

In September 2002, surface water leaving the lake was gauged and measured to be 0.39 cfs. At the same time Aeneas Creek was gauged at 5.5 cfs, Jones Creek was gauged at 3.4 cfs, and Graves Creek was gauged at 7.2 cfs. Based on these measurements the Prenfish concentration in Graves Creek downstream of the Aeneas Creek confluence would be approximately 0.02 ppm.

Bighawk Lake will require 204 gallons (1,999 pounds) of Prenfish, administered at 1 ppm, to remove the fish from it. This would be transported to the lake by helicopter in 3 loads. Two flights will be required to transport a raft, motor, sprayers and drip stations. Five people will be needed to treat the lake and will require two flights to transport. This lake is shaped like a large figure "8" and will require ½ of the Prenfish to be applied to the upper lobe, then the raft will be walked through a narrow channel that separates the two lobes, and the second ½ will be applied to the lower lobe. Before the treatment begins, monitors will set up a fish cage on Graves Creek just below the confluence of Aeneas Creek to evaluate detoxification. This site is located approximately 385 feet downstream of forest road 9797 crossing and would be accessed by foot. The monitor at this site will have a potassium permanganate detoxification station ready to administer if caged fish show signs of distress. After the treatment, three people will be flown out with most of the equipment. Two people will stay at the site and monitor the treatment. The following day, dead fish will be collected from the shoreline, taken to deeper water and sunk. Thereafter the remaining equipment (drip station, sprayers, raft and motor) will be removed.

MFWP angler use statistics from 1989 through 2001 indicate Lower Bighawk Lake receives an estimated 60 angler days per year (Table 12). Based on this, the lake would be restocked with genetically pure westslope cutthroat trout from the Washoe Park State Fish Hatchery to maintain the fishery. Beginning in July following the treatment 2,700 fish would be stocked each year for three years. The population would be evaluated on year five post treatment to determine population viability and future stocking needs. The risk of reinvasion from downstream fish is low to non-existent due to the high gradient of the outflow stream and the fact that downstream fish will be removed during the treatment

Margaret Lake is a 46.5-acre lake located on the Flathead National Forest at 5,575 feet above sea level and forms the headwaters of Forest Creek. The lake has a maximum depth of 79 feet and a total volume of 1,962 acre-feet (Figure B10). Small ephemeral streams and spring seeps provide most of the surface water inflow to Margaret Lake. Forest Creek flows out of Margaret Lake and continues for 3.9 miles before it enters Hungry Horse Reservoir. There is a culvert barrier located on road 895, approximately 0.9 mile up from the mouth of Forest Creek. Total distance from the fish barrier to Margaret Lake is 3.0 miles. There are three unnamed tributaries that enter Forest Creek between Margaret Lake and it's mouth.

Access to Margaret Lake is made by a 1.3 mile long trail that continues off Forest Road 895E in the Forest Creek drainage. U of M genetics lab tests indicate the lake harbors a population of hybrid westslope cutthroat X Yellowstone cutthroat trout. MFWP records indicate the lake was stocked once with generic cutthroat trout in 1948. From 1982 through 1992 it was stocked five times with pure westslope cutthroat trout. An amphibian survey conducted in 2001 did not detect any amphibians (Maxell 2002).

Forest Creek is the outflow stream of Margaret Lake. Three separate genetic samples taken from Forest Creek indicate the population is hybridized westslope cutthroat X Yellowstone cutthroat and/or rainbow trout.

The management objective for this lake is to remove the hybrid trout from the lake and from the 3.0 miles of stream between the lake and road 895 culvert barrier. To achieve this objective, Prenfish would be applied to the lake at the prescribed rate of 1 ppm. Water leaving the lake would be allowed to flow downstream in an effort to remove as many hybrid trout from downstream as possible. We would rely on fresh water inputs from two unnamed tributaries to Forest Creek to dilute the water and if necessary use potassium permanganate if necessary. Up-to-date flow measurements and on-site bioassays would determine if detoxification measures are necessary beyond the road 895 crossing. Caged live fish would be set in Forest Creek at the crossing of road 895 and at the creek mouth to measure the toxicity of water. As an added safeguard measure, we would rely on Hungry Horse Reservoir to further dilute the stream water.

In October 2002, Forest Creek was gauged at the forest road 895 crossing and measured to be 2.9 cfs. At the same time Margaret Lake was surveyed and outflow was estimated to be < 1cfs. From the air, Forest Creek was observed to flow subsurface for approximately 100 yards at a site 1/3 mile below the lake outlet. Based on these observations and measurements, Prenfish would be expected to detoxify during subterranean stream flow. If the stream flowed subsurface, a drip station would be installed at the point where the stream resurfaced to administer 1 ppm Prenfish for 8 hours. If surface water was flowing continually, freshwater inputs from the two unnamed tributaries in Forest Creek should dilute the Prenfish concentration to approximately 0.34 ppm. This represents a 66% reduction in concentration. In addition, interaction with organic substances, oxidation by stream flow and sunlight is expected to further neutralize the Prenfish over the 3-mile distance.

Margaret Lake will require 654 gallons (6,409 pounds) of Prenfish, administered at 1 ppm, to remove the fish from it. This would be transported to the lake by SEAT in two 250-gallon loads and a helicopter would transport the remaining 154 gallons in 2 loads. Two flights will be required to transport rafts, motors, sprayers and drip stations. Six people will be needed to treat the lake and will require two flights to transport. In August 2002, Margaret Lake was surveyed by air with SEAT pilot Andy Taylor of Taylor Aviation in Fort Benton, Montana and a project fisheries biologist. The pilot indicated that he was uncertain whether SEAT could be used on this lake and recommended further investigation with a slower aircraft. Margaret Lake measures approximately 2,252 feet long by 1,189 feet wide. In November 2002, mach flyovers were conducted in a Hughes 500 helicopter to survey the terrain features and develop an application plan. Pilot Andy Taylor indicated that SEAT could be used for application and the best approach to Margaret Lake would be from the southwest corner. The plane would approach and make its descent toward the lake, make a slight bank to the east, dispense it's load and continue easterly down Forest Creek. Taylor further recommended that two separate loads of 250 gallons each be administered to maximize aircraft performance. After the first load is administered the plane would return to Glacier International Airport to be loaded with the remaining 250 gallons, return to the lake, and apply the final load.

Before the treatment begins, monitors will set up a fish cage on Forest Creek at forest road 895F to evaluate detoxification. The monitor at this site will have a potassium permanganate detoxification station ready to administer if caged fish show signs of distress. After the treatment, four people will be flown out with most of the equipment. Two people will stay at the site and monitor the treatment. The following day, dead fish will be collected from the shoreline, taken to deeper water and sunk. Thereafter the remaining equipment, drip station, sprayers, raft and motor will be removed. Caged fish stations will be monitored for 48 hours, and then removed. If potassium permanganate needs to be applied, it will be applied for 48 hours.

Margaret Lake would be restocked with genetically pure westslope cutthroat trout from the Washoe Park State Fish Hatchery. Beginning in July following the treatment 4,700 fish, of which approximately 1000 would be of catchable size, would be stocked in each of the first two years to restore the fishery as quickly as possible. The population would be evaluated on year five post treatment to determine population viability and future stocking needs. The risk of reinvasion by downstream fish into the lake is low to non-existent due to the steep gradient of the stream and the fact that downstream fish will be removed during the treatment.

<u>Sunburst Lake</u> is a 148.5-acre lake located in the Bob Marshall Wilderness at 5,322 feet above sea level. The maximum depth of the lake is 221 feet and the lake volume is 12,687 acre feet (Figure B11). There are at least 10 surface water inputs to the lake including perennial streams, ephemeral streams and freshwater seeps. These occur around the entire shoreline of the lake, but are more abundant on the south and west shores. Gorge Creek flows out of the lake for 1.53 miles where it meets the confluence with Inspiration Creek. The stream continues for 3.64 miles where it meets Stadium Creek, then for 1.61 miles where it reaches Feather Creek, then for 0.76 mile where it reaches a barrier waterfall. Gorge Creek continues for 1.36 miles where it reaches the confluence of Bunker Creek. Bull trout use Bunker Creek as a spawning and rearing stream, but at very low levels. Total distance from Sunburst Lake to the barrier falls is 7.54 miles.

Sunburst Lake can be accessed by a 10.7-mile long trail beginning at the Napa Point trailhead. Although this is the closest access, poor trail conditions down Inspiration Creek drainage preclude use by large numbers of stock. Rather, access to the lake would best be gained by trail 218 starting at the Gorge Creek trailhead and traveling 10.9 miles up Gorge Creek drainage to the lake. U of M genetics lab tests indicate the lake contains predominantly westslope cutthroat trout hybridized with Yellowstone cutthroat trout and rainbow trout. MFWP records indicate the lake was stocked with Yellowstone cutthroat trout in 1939 and in 1950. From 1989 through 2000 it was stocked nine times with pure westslope cutthroat trout. An amphibian survey conducted in 2001 detected garter snakes at the lake. Columbia spotted frogs were detected at neighboring Olor lakes located 1.1 mile to the northwest of Sunburst Lake and long toed salamanders and Columbia spotted frogs were detected at Inspiration lakes located 2.4 miles northwest of Sunburst Lake (Maxell 2002).

Gorge Creek flows out of Sunburst Lake. A genetic test form Gorge Creek indicates the population is hybrid westslope cutthroat trout X Yellowstone cutthroat trout.

The management objective for this lake is to remove the hybrid trout from the lake and from the 6.1 miles of stream between the lake and the waterfall near Feather Creek. To achieve this objective, antimycin would be used because it is the quickest method for removal, it requires the least amount of material, making transport to a remote location easier, and it naturally detoxifies with every 200 feet of downstream elevation drop, making containment easier. The elevation differential between Sunburst Lake and the waterfall near Feather Creek is approximately 1,875 feet, which would require installing approximately 7 recharge stations to maintain lethality of the antimycin through this reach of stream. Forest Service trails 693 and 218 parallel Gorge Creek, which makes access easier. For this project, the barrier waterfall near the mouth of Feather Creek is the lower boundary of the treatment area. Up to date flow measurements and on-site bioassays would be used to determine the level of natural detoxification. As a safeguard measure, caged fish would be placed in Gorge Creek upstream of the waterfall near Feather Creek and if natural detoxification were not effective, potassium permanganate would be administered at the rate of 1ppm to detoxify the antimycin.

The 2,537 units (9,513 pounds) of antimycin needed to treat Sunburst Lake and Gorge Creek would require 55 mule loads. This could be conducted using 5 eleven-animal strings over 2 weeks. An attended camp would be set at Sunburst Lake to store the materials. Eight personnel would be required to treat the lake, another eight to treat the stream and one to monitor the caged fish and set up a detoxification station if needed. All personnel would access the project site by horse. Eight additional mules would transport supplies, materials, four rafts and motors. Boat motors would be used to distribute the compound near the surface and pumps would be used to distribute the compound at deeper depths. The treatment of Sunburst Lake and Gorge Creek would be conducted in mid to late September to take advantage of warmer water temperature and thus facilitate an effective treatment. The treatment of the lake and stream is expected to take two days for set up, one day for application, and two days for clean-up and leaving the site.

Sunburst Lake would be restocked with pure westslope cutthroat trout from the Washoe Park State Fish Hatchery in Anaconda. MFWP records indicate Sunburst Lake receives an average of 96 (39-175) angler days per year. It's annual statewide ranking is number 965 out of 1,529 fisheries in the state (Table 12). Restocking genetically pure westslope cutthroat would maintain angling opportunity at Sunburst Lake, provide a source of pure fish to repopulate downstream, genetically dilute any possible remaining westslope X Yellowstone hybrids and reduce the potential for an illegal fish introduction. Restocking the lake would likely have no impacts to garter snakes that occur at the lake, or with Columbia spotted frog and longtoed salamanders that occur in the vicinity, as they currently co-exist with trout in the lake. Maintenance stocking would continue on Sunburst Lake to maintain population viability and angling quality. Stocking would occur the July following the treatment and continue for two more years. Approximately 14,800 fish, of which 1,000 would be of catchable size, would be stocked in each of the first two years to restore the fishery as quickly as possible. The population would be evaluated on year five post treatment to determine population viability and stocking needs. Reinvasion by downstream fish into Sunburst Lake is possible, but to what extent is unknown. Gorge Creek has several likely waterfall barriers that may prevent upstream movement of fish. The fact that fish in Gorge Creek will be removed during the treatment, down to the barrier near its mouth, makes reinvasion unlikely.

<u>Woodward Lake</u> is a 65-acre lake located in the Bob Marshall Wilderness at 6,433 feet above sea level. The lake is located 0.9 mile downstream of Rubble Lake (fishless) and forms the headwaters of Cataract Creek. The maximum lake depth is 119 feet and total volume is 2,255 acre feet (Figure B12). The main surface water inputs to the lake include seeps along the northwest shore from upland snowfields, ephemeral streams on the west and north shores, and several seeps on the south shore. Four of the water basins in the Necklace Lakes chain drain into Woodward Lake. Surveys in July 2002 revealed that these basins are fishless and their outlet streams flowed subsurface shortly after leaving the Necklace plateau. Cataract Creek flows out of the lake, then for 0.7 mile where Terrace Creek joins it from the north. It flows for another 2.26 miles before meeting the confluence with Big Salmon Creek. Big Salmon Creek flows for 1.6 miles where it meets Dart Creek from the west, then continues for 1.9 miles before meeting the confluence with Tango Creek from the northwest. It continues for 0.21 mile before meeting Gyp Creek from the south, then for 1.1 mile before meeting the barrier falls. This barrier falls is the uppermost known distribution of bull trout in the Big Salmon drainage. Total distance from Woodward Lake to the barrier falls is 7.73 miles. Big Salmon Creek continues for 4.84 miles until it reaches Big Salmon Lake.

Access to Woodward Lake is made by a 9.5-mile long trail that begins at the Owl Creek trailhead. Empirical information indicates the lake harbors a population of rainbow trout. A limited amount of testing from the U of M genetics lab indicates the lake contains rainbow trout and westslope cutthroat trout. MFWP records indicate the lake was stocked with rainbow trout in 1928. In 1930, 1936 and 1939 it was stocked with generic cutthroat trout. From 1986 through 2000 it was stocked fourteen times with pure westslope cutthroat trout. The fact that Woodward Lake was stocked with the generic 002 cutthroat, suggests it contains Yellowstone cutthroat trout genes also. An amphibian survey conducted in 2001 detected Columbia spotted frogs at the lake. Spotted frogs and long toed salamanders were observed at approximately 16 locations in Necklace Lakes chain located 0.38 mile to the south and at three sites in the Terrace Lakes complex located 0.63 mile to the north (Maxell 2002).

Cataract Creek is the outflow stream from Woodward Lake. A genetic sample taken in 2000 from Cataract Creek near its mouth revealed the population was 91% rainbow and 9% westslope cutthroat.

The management objective for this lake is to remove the hybrid trout from the lake and from the 2.96 miles of stream between Woodward Lake and the Cataract/Big Salmon Creek confluence. To achieve this objective, antimycin would be used because it is the quickest method for removal, it requires the least amount of material making transport to a remote location easier, and it naturally detoxifies with every 200 feet of downstream elevation drop making containment easier. The elevation differential between Woodward Lake and the mouth of Cataract Creek is approximately 993 feet, which would require installing 4 recharge stations to maintain lethality of the antimycin through this reach of stream. For this project, the mouth of Cataract Creek is the lower boundary of the treatment area. This is 4.81 miles upstream of the barrier falls on Big Salmon Creek, which is the uppermost known distribution of bull trout in the drainage. The elevation differential from the mouth of Cataract Creek to the Barrier Falls is approximately 950 feet which is 4.75 times more than is required to detoxify the antimycin. Furthermore, we would rely on fresh water input from Big Salmon, Dart, Tango, and Gyp creeks to dilute the antimycin. As a safeguard measure, caged fish would be placed in Cataract Creek near the mouth, and in Big Salmon Creek near the confluence of Dart Creek. If natural detoxification were not effective, potassium permanganate would be administered at the rate of 1ppm to detoxify the antimycin.

Cataract Creek was gauged in July 2002 near it's mouth and discharge was measured to be 22.1 cfs. Big Salmon Creek was gauged near this confluence and found to be 16.6 cfs. Based on these measurements, dilution of Cataract Creek by Big Salmon Creek is expected to be at least 43% in volume. Up to date flow measurements and on-site bioassays would be used to determine to what extent we could rely on flow time and dilution to detoxify antimycin. As an added safeguard measure, a potassium permanganate detoxification station would be set up and ready to implement if natural detoxification and dilution were not sufficient.

The 451 units of antimycin (1,691 pounds) needed to treat Woodward Lake and Cataract Creek would require approximately 10 mule loads. This could be conducted using 2 five-animal strings just days before the treatment. An attended camp would be set at Woodward Lake to store the materials. Six personnel would be required to treat the lake, another four to treat the stream and one to monitor the caged fish and set up a detoxification station if needed. These eleven people would each need one riding horse and six mules for supplies, materials, rafts, motors and feed. Two outboard motors would be required to administer the antimycin in a timely manner and to mix the compound with lake water. Pumps would be used to distribute the compound at deeper depths. The treatment of Woodward Lake and Cataract Creek would be conducted between mid September and early October. The treatment of the lake and stream is expected to take two days for set up, one day for application, and two days for clean-up and leaving the site.

Woodward Lake would be restocked with pure westslope cutthroat trout from the Washoe Park State Fish Hatchery in Anaconda. MFWP records indicate Woodward Lake receives an average of 156 (34-572) angler days per year (Table 12). It's annual statewide ranking is number 732 out of 1,529 fisheries in the state. Restocking genetically pure westslope cutthroat would maintain angling opportunity at Woodward Lake, provide a source of pure fish to repopulate downstream, genetically dilute any possible remaining rainbow or rainbow westslope hybrids downstream, and reduce the potential for an illegal fish introduction. Restocking the lake would likely have no impacts to Columbia spotted frogs as they are currently co-exist with trout in the lake. Maintenance stocking would continue on Woodward Lake to maintain population viability and angling quality. Beginning in July following the treatment 6,500 fish, of which 1,000 would be of catchable size, would be stocked in each of the first three years to restore the fishery as quickly as possible. The population would be evaluated on year five post treatment to determine population viability and future stocking needs. The risk of reinvasion by downstream fish into Woodward Lake is low due to the high gradient stream below the lake makes upstream passage difficult if not impossible, and also downstream fish would be removed during the treatment.

The Necklace chain of lakes is also known as the Smokey Creek Lakes. This complex consists of approximately 15 water basins, but eleven of them comprise the majority of surface water in the complex, and the four largest lakes comprise the majority of the hybrid fish in the complex (Figure B13). Although there are 15 lakes in the complex, repeatedly throughout this specialist report, the Necklace Lakes have been referred to as having 4 main basins. Prior to 2002, two of the 11 lakes, numbers 3 and 10 (identified from Figure B13), were believed to drain into the Smokey Creek drainage, but a survey in 2002 revealed that they flow into the Cataract Creek drainage. The other nine lakes, and any connected basins are targeted for this project.

The Necklace lakes are located in the Bob Marshall Wilderness at approximately 6,480 feet above sea level and form the headwaters of Smokey Creek. Total surface acreage of the nine largest lakes (numbers 1,2,4,5,6,7,8,9,11) is 42.8 acres. Total volume of these nine lakes is approximately 324 acre-feet, and maximum depth of the deepest lake is 28.5 feet (Figures B14, B15, B17, B18, B19, B20, B21, B22, B24). Smokey Creek flows out of the Lower Necklace Lake and continues 1.94 miles down to the confluence of Big Salmon Creek. The Smokey Creek confluence with Big Salmon Creek is 0.17 mile upstream of the Cataract Creek confluence. Big Salmon Creek flows for 1.6 miles where it meets Dart Creek from the west, then continues for 1.9 miles before meeting the confluence with Tango Creek from the northwest. It continues for 0.21 mile before meeting Gyp Creek from the south, then for 1.1 mile before meeting the barrier falls. This barrier falls is the uppermost known distribution of bull trout in the Big Salmon drainage. Total distance from Necklace lakes to the barrier falls is 6.92 miles.

Access to the Necklace lakes is made by an 8.7-mile long trail that begins at the Owl Creek trailhead. U of M genetics lab tests indicates the lakes contain predominantly rainbow trout hybridized with westslope and Yellowstone cutthroat trout. MFWP records indicate the lakes were stocked with rainbow trout in 1928. From 1987 through 2001 they were stocked thirteen times with pure westslope cutthroat trout. An amphibian survey conducted in 2001 detected Columbia spotted frogs and long toed salamanders at approximately 16 locations in Necklace lakes chain (Maxell 2002).

Smokey Creek is the outflow stream from the Necklace chain of lakes. A genetic sample taken in 2000 from Smokey Creek near its mouth revealed the population was hybridized and comprised of 61% westslope cutthroat, 39% Yellowstone cutthroat and, <1% rainbow trout.

The management objective for this lake complex is to remove the hybrid trout from the lakes, from the stream segments between the lakes, and from the 2.1 miles of stream between lower Necklace Lake and the Cataract/Big Salmon creek confluence. To achieve this objective, antimycin would be used because it is the quickest method for removal, it requires the least amount of material making transport to a remote location easier, and it naturally detoxifies with every 200 feet of downstream elevation drop making containment easier. The elevation differential between Necklace lakes and the mouth of Smokey Creek is approximately 1080 feet, which would require installing 5 recharge stations to maintain lethality of the antimycin through this reach of stream. Forest Service trail 110 parallels much of Necklace lakes and Smokey Creek making installation of booster stations easier. For this project, the confluence of Cataract and Big Salmon creeks is the lower boundary of the treatment area. This location is 4.8 miles upstream of the barrier falls on Big Salmon Creek, which is the uppermost known distribution of bull trout in the drainage. The elevation differential from the mouth of Cataract Creek to the Barrier Falls is approximately 950 feet which is 5 times more than is required to detoxify the antimycin. Furthermore, we would rely on fresh water input from Big Salmon, Cataract, Dart, Tango, and Gyp creeks to dilute the antimycin. As a safeguard measure, caged fish would be placed in Smokey Creek near the mouth, and in Big Salmon Creek near the Dart Creek confluence.

Based on stream gauging measurements of Big Salmon Creek in July of 2002, empirical calculations of the input of Smokey Creek indicate the stream was flowing slightly greater than 10 cfs. Based on theses estimates, antimycin treated water leaving Smokey Creek is expected to be diluted by Big Salmon Creek ($\pm$ 6 cfs) and Cataract Creek (22.1 cfs) by approximately 73% in volume. Up to date flow measurements and on-site bioassays will be used to determine if the amount of dilution and flow time is sufficient. A potassium permanganate detoxification station would be set up and ready to implement if necessary.

The 64 units (240 pounds) of antimycin required to treat the Necklace lakes complex and Smokey Creek would be transported with 2 mule loads. Fourteen people would be required to conduct the treatment; 8 for the lakes, 5 for Smokey Creek and 1 to monitor the caged fish and administer the potassium permanganate if necessary. These fourteen people would require one horse each. The four rafts with motors, sprayers, recharge stations and camp supplies would require approximately 9 mule loads. The treatment would consist of four days; one for set up, one for treatment and two for clean up and exit.

All of the necklace lakes would be restocked with pure westslope cutthroat trout from the Washoe Park State Fish Hatchery in Anaconda. MFWP records indicate Necklace receives an average of 118 (46-189) angler days per year (Table 12). It's annual statewide ranking is number 869 out of 1,529 fisheries in the state. Restocking genetically pure westslope cutthroat in the lower lakes would maintain angling opportunity at Necklace lakes, provide a source of pure fish to repopulate downstream, genetically dilute any possible remaining rainbow or rainbow westslope hybrids and reduce the potential for an illegal fish introduction. Restocking the lakes would likely have no impacts to Columbia spotted frogs and long toed salamanders as they currently co-exist with trout in the lake complex and are quite ubiquitous. Maintenance stocking would continue in the Necklace chain of lakes to maintain population viability and angling quality. Beginning in July following the treatment, 1,400 fish would be stocked each year for three years among lakes 1, 5, 6, 8, and 11. The populations would be evaluated on year five post treatment to determine population viability and determine future stocking needs. The risk of reinvasion by downstream fish into the Necklace lakes is unlikely due to the high gradient of the stream below the lakes and the fact that downstream fish would be removed during the treatment.

Lena Lake is a 74.2-acre lake located in the Bob Marshall Wilderness at 6,732 feet above sea level. The maximum lake depth is measured at 80 feet and lake volume is 2,547 acre-feet (Figure B25). The main surface water inputs to the lake include an ephemeral stream on the southern shore, which presumably receives water from an unnamed basin located 0.4 mile to the south, and a few seeps along the east and west shores. The water flowing out of Lena Lake forms Big Salmon Creek, which flows for 1.79 miles to the confluence with Feline Creek, which enters from the southwest. Big Salmon Creek continues for 1.57 miles to Pendant Creek, which enters from the west, then for 0.92 mile to a barrier waterfall. This waterfall is directly above the Smokey Creek confluence. The Smokey Creek confluence with Big Salmon Creek is 0.17 mile upstream of the Cataract Creek confluence. Big Salmon Creek flows for 1.6 miles where it meets Dart Creek from the west, then continues for 1.9 miles before meeting the confluence with Tango Creek from the northwest. It continues for 0.21 mile before meeting the confluence with Gyp Creek from the south, then for 1.1 mile before meeting the barrier falls. This barrier falls is the uppermost known distribution of bull trout in the Big Salmon drainage. Total distance from Lena Lake to the barrier falls is 9.26 miles.

Access to the Lena Lake is made by a 16.2 mile long trail that begins at the Owl Creek trailhead. U of M genetics lab tests indicates the lake contains a high percentage of rainbow trout and rainbow X westslope cutthroat hybrids. MFWP records indicate the lake was stocked with rainbow trout in 1928. From 1986 through 2000 it was stocked thirteen times with pure westslope cutthroat trout. An amphibian survey conducted in 1999 detected adult Columbia spotted frogs (USFS 1999).

Big Salmon Creek is the outflow stream from Lena Lake. Genetic samples taken in Big Salmon Creek from 1987 through 2000 indicate the population above Pendant Creek confluence is hybridized westslope cutthroat X rainbow trout.

The management objective for this lake is to remove the hybrid trout from the lake and from the 4.25 miles of Big Salmon Creek between Lena Lake and the Cataract Creek confluence. To achieve this objective, antimycin would be used because it is the quickest method for removal, it requires the least amount of material making transport to a remote location easier, and it naturally detoxifies with every 200 feet of downstream elevation drop making containment easier. The elevation differential between Lena Lake and the mouth of Cataract Creek is approximately 1,292 feet, which would require installing 5 recharge stations to maintain lethality of the antimycin through this reach of stream. Forest Service trails 212 and 225 parallel much of upper Big Salmon Creek making installation of drip stations easier. For this project, the mouth of Cataract Creek is the lower boundary of the treatment area. This location is 4.8 miles upstream of the barrier falls on Big Salmon Creek, which is the uppermost known distribution of bull trout in the drainage. The elevation differential from the mouth of Cataract Creek to the Barrier Falls is approximately 950 feet, which is 4.75 times more than is required to detoxify the antimycin. Furthermore, we would rely on fresh water input from Cataract, Dart, Tango, and Gyp creeks to dilute the antimycin. As a safeguard measure, caged fish would be placed in Big Salmon Creek near the Cataract confluence, and near the Dart Creek confluence. If natural detoxification were not effective, potassium permanganate would be administered at the rate of 1ppm to detoxify the antimycin.

In July 2002 discharge of Big Salmon Creek was measured at three locations; at the outlet of Lena Lake it was 1.36 cfs, at Pendant Cabin it was 5.48 cfs, and near the confluence with Cataract Creek it was 16.56 cfs. Cataract Creek was gauged at 22.1 cfs. Based on theses measurements, antimycin treated water leaving Lena Lake would be diluted at this point by 80% in volume. Up to date flow measurements and on-site bioassays will be used to determine if the level of dilution and flow time are sufficient. A potassium permanganate detoxification station would be set up and ready to implement if natural detoxification and dilution were insufficient.

Transportation of materials, equipment and personnel would be accomplished using livestock. Motorized rafts would be used to administer the antimycin. The 507 units (1,900 pounds) of antimycin needed to treat the lake and creek would require 11 mule loads. An attended camp would be set at Lena Lake to store the materials. An additional 4 mules would be required to transport the drip stations, rafts, motors and sprayers. Approximately five people would be needed to treat the lake, five to man drips stations on the stream and one to monitor caged fish and administer the potassium permanganate if necessary. Aside from the stock needed to transport antimycin, approximately 18 riding and pack animals would be needed to transport personnel, miscellaneous equipment, feed and camp materials. The time required to pack materials to the site would be about 6 days. Thereafter, the treatment would require one day, two days for clean up and leave on the fourth day.

Lena Lake would be restocked with pure westslope cutthroat trout from the Washoe Park State Fish Hatchery in Anaconda. MFWP records indicate it receives an estimated 165 angler days per year. It's annual statewide ranking is number 712 out of 1,529 fisheries in the state (Table 12). Restocking genetically with pure westslope cutthroat would maintain angling opportunity at Lena Lake, provide a source of pure fish to repopulate downstream, genetically dilute any possible remaining rainbow or rainbow westslope hybrids and reduce the potential for an illegal fish introduction. Restocking the lake would likely have no impacts to Columbia spotted frogs and long toed salamanders as they are currently co-exist with trout in the lake complex. Maintenance stocking would continue in Lena Lake to maintain population viability and angling quality. Stocking would occur the July following the treatment with 7,400 fish each year for three years. The population would be evaluated on year five post treatment to determine population viability and future stocking needs. The risk of reinvasion by downstream fish into Lena Lake is unknown based on present information regarding fish barriers on Big Salmon Creek. Because fish will be removed from the stream between Lena Lake and the Barrier Falls near the Smokey Creek confluence during the treatment, the risk of reinvasion is low.

<u>Lick Lake</u> is a 19-acre lake located in the Bob Marshall Wilderness at 5,984 feet above sea level. The maximum lake depth is estimated at 27 feet and lake volume is 141 acre feet (Figure B26). The main surface water inputs to the lake include one high gradient stream near the outlet on the northwest shore, and three ephemeral streams on the southern shore. The water in Lick Lake is high in glacial silt and often appears milky white in color, with very little apparent light penetration. Fish have been observed spawning in the outlet. Lick Creek flows out the lake for 0.71 mile to an unnamed tributary that enters from the north, then

for 2.38 miles to the confluence with Gordon Creek. Gordon Creek flows for another 0.87 mile where it reaches the Doctor Creek confluence, then for 1.06 mile to the confluence with George Creek. There is a suspected barrier waterfall on Gordon Creek immediately above its confluence with George Creek. For bull trout that migrate from the South Fork Flathead River, this is the furthest known upstream distribution of bull trout in Gordon Creek. MFWP file data document the presence of bull trout and mountain whitefish in Doctor Lake. It is believed that Doctor Creek below the lake also provides habitat for this disjunct population of bull trout. In 2000, Gordon Creek was electrofished upstream of the confluence with Doctor Creek for 0.4 hours and no bull trout were observed (Rumsey and Cavigli 2000). August 2002 Gordon Creek was electrofished for 1.42 hours , upstream of the Doctor Creek confluence, and only two juvenile bull trout were discovered in the first 0.2 miles. Two large rock waterfalls approximately 0.2 mile upstream of the confluence are believed to limit upstream distribution beyond this point. No bull trout were observed upstream of this point. The distance from Lick Lake to the uppermost distribution of bull trout is 3.6 miles.

There is no maintained trail to Lick Lake. Access to the lake is gained by cross country hiking off of trail 35 in section 4 just south of Gordon Pass. U of M genetics lab tests indicates the lake contains hybrid westslope cutthroat trout X Yellowstone cutthroat trout. MFWP records indicate the lake was stocked with generic cutthroat trout in 1928 and 1930, and with Yellowstone cutthroat trout in 1938 (Huston 1988). From 1988 through 2000 it was stocked eleven times with pure westslope cutthroat trout. An amphibian survey conducted in 2001 detected Columbia spotted frogs and garter snakes. Columbia spotter frogs and long toed salamanders were detected at two unnamed waters 0.76 mile to the north of Lick Lake (Maxell 2002).

Lick Creek is the outflow stream from Lick Lake. Genetic samples taken from Lick Creek in 2000 indicate the population hybridized westslope cutthroat X Yellowstone cutthroat trout.

The management objective for this lake is to remove the hybrid trout from the lake and from the 3.7 miles of stream between the lake and the rock waterfalls near the Doctor Creek confluence (approximately 0.2 miles upstream of the Doctor Creek confluence). To achieve this objective, antimycin would be used because it is the quickest method for removal, it requires the least amount of material making transport to a remote location easier, and it naturally detoxifies with every 200 feet of downstream elevation drop making containment easier. The elevation differential between Lick Lake and the known bull trout population in Gordon Creek is approximately 704 feet, which would require installing 2 recharge stations to maintain lethality of the antimycin. For this project, the area directly upstream of the Doctor/Gordon Creek confluence is the lower boundary of the treatment area. The stream should be sufficiently detoxified by this point. Furthermore, we would rely on fresh water input from one unnamed tributary to Lick Creek and Gordon Creek to dilute the antimycin. As a safeguard measure, caged fish would be placed in Gordon Creek upstream of the Doctor Creek confluence. If natural detoxification were not effective, a potassium permanganate detoxification station would be set up and ready to administer if necessary. Up to date flow measurements and on-site bioassays would determine the level of natural detoxification available.

Because there is no trail to Lick Lake, materials, equipment, and personnel would be transported using a helicopter. Motorized rafts would be used to administer the antimycin. The 28 units (105 pounds) of antimycin needed to treat the lake and creek would require one helicopter load. An attended camp would be set at Lick Lake to store the materials. Three additional helicopter loads would be required to transport motors, sprayers and equipment. Four people would be needed to treat the lake. Two people would be needed to monitor the drip stations on the creek and another to monitor caged fish and administer potassium permanganate if necessary. Livestock would be used to deliver the materials needed to install the single drip station and the potassium permanganate for supplemental detoxification. The treatment would require one for set up, one day to administer and two days for clean up then departure. Personnel and equipment would be flown out from the site when clean up is finished.

Lick Lake would be restocked with pure westslope cutthroat trout from the Washoe Park State Fish Hatchery in Anaconda. MFWP records indicate it receives an estimated 88 angler days per year. It's annual statewide ranking is number 983 out of 1,529 fisheries in the state (Table 12). Restocking genetically pure westslope cutthroat would maintain angling opportunity at Lick Lake, provide a source of pure fish to repopulate downstream, genetically dilute any possible remaining westslope X Yellowstone cutthroat hybrids and reduce the potential for an illegal fish introduction. Restocking the lake would likely have no impacts to

Columbia spotted frogs and garter snakes as they currently co-exist with trout in the lake. Maintenance stocking would continue in Lick Lake to maintain population viability and angling quality. Stocking would occur the July following the treatment with 1,900 fish and continue for two years after. The population would be evaluated on year five post treatment to determine population viability and future stocking needs. In 2002, MFWP personnel hiked downstream from Lick Lake to the Gordon creek/Doctor Creek confluence. Several large rock waterfalls observed in this reach of stream suggests that risk of reinvasion by downstream fish into lick Lake is very low. Furthermore, the fact that downstream fish would be removed during the treatment makes this risk low.

Koessler Lake is a 86.5-acre lake located in the Bob Marshall Wilderness at 6,010 feet above sea level. The maximum lake depth is 173 feet and lake volume is 5,731 acre-feet (Figure B27). The main surface water inputs to the lake include two streams on the southwest shore. The lake has a submerged island near the southeast corner, which is visible from the air. The outlet stream from Koessler Lake is unnamed and flows for 0.93 mile before reaching the confluence with Doctor Creek. The stream gradient in this short reach is 11.5%. From this point, Doctor Creek flows for 1.62 miles to its confluence with Gordon Creek. Gordon Creek then continues for 1.06 mile to the confluence with George Creek. There is a suspected barrier waterfall on Gordon Creek immediately above its confluence with George Creek. This is the furthest known upstream distribution of bull trout in Gordon Creek that migrate from the South Fork Flathead River. MFWP file data document the presence of bull trout in Doctor Lake. It is believed that Doctor Creek below the lake also provides habitat for this disjunct population of bull trout. The section of Doctor Creek between the Koessler Creek confluence and the mouth of Doctor Creek was electrofished in 2000 (Rumsey and Cavigli) and again in 2002. In 2000, a single juvenile bull trout was captured during electrofishing for 1.2 hours. In 2002 four sites were electrofished for a total of 1.1 hours and two juvenile bull trout were captured and a third one was observed but not captured. The distance from Koessler Lake to the suspected habitat of Doctor Creek bull trout is 0.93 miles.

Access to Koessler Lake is made by traveling 15 miles on trails 35 and 291 beginning at Owl Creek trailhead. U of M genetics lab tests indicates the lake contains hybrid westslope cutthroat trout X Yellowstone cutthroat trout. MFWP records indicate the lake was stocked with Yellowstone cutthroat trout in 1928, 1930 and 1965 (Huston 1988). From 1988 through 2000 it was stocked eleven times with pure westslope cutthroat trout. An amphibian survey conducted in 2001 detected long toed salamander, Columbia spotted frogs and garter snakes (Maxell 2002).

The management objective for this lake is to remove the hybrid trout from the lake. To achieve this objective, antimycin would be used because it is the quickest method for removal, it requires the least amount of material making transport to a remote location easier, and it naturally detoxifies with every 200 feet of downstream elevation drop making containment easier. The elevation differential between Koessler Lake and Doctor Creek is approximately 580 feet, which allows the antimycin to be detoxified by elevation drop nearly 3 times over before it reaches Doctor Creek. Given the proximity of bull trout in the Doctor Creek, we will allow the water in the Koessler Lake outflow stream to naturally detoxify using elevation drop. There will be no supplemental antimycin drip stations placed on this stream. We would also rely on fresh water input from Doctor Creek to further dilute the antimycin. Forest Service trail 291 crosses the Koessler Lake outflow stream near its mouth. As a safeguard measure, caged fish would be placed in this stream at the trail crossing, and at an intermediate site between the trail crossing and the lake to measure toxicity of antimycin in the stream. Up to date flow measurements and on-site bioassays would be used to determine the level of dilution and stream flow time. If these assays determined that natural detoxification would not be sufficient, potassium permanganate would be administered at the rate of 1ppm to detoxify the antimycin.

In August 2002 discharge of Koessler Creek was measured near its mouth at 5.13 cfs. At the same time Doctor Creek was measured just above this confluence at 3.76 cfs. Based on theses measurements, antimycin treated water leaving Koessler Lake would be diluted by water from Doctor Creek by 64% in volume.

Transporting the 1,146 units (4,298 pounds) of antimycin needed to treat the lake would require approximately 25 mule loads. This could be conducted using approximately 4 six animal strings in 1 week. An attended camp would be set at Koessler Lake to store the materials. The additional materials, rafts, motors and camp would require approximately five mule loads. Two outboard motors would be required to administer the antimycin in a timely manner and to mix the compound with lake water. Pumps would be used to distribute the compound at deeper depths. The time required to pack all materials and equipment to the site would be about 10 days. Thereafter, the treatment would require one day, two days for clean up and leave on the fourth day.

Koessler Lake would be restocked with pure westslope cutthroat trout from the Washoe Park State Fish Hatchery in Anaconda. Restocking genetically pure westslope cutthroat would maintain angling opportunity at Koessler Lake, provide a source of pure fish to repopulate downstream, genetically dilute any possible remaining westslope X Yellowstone cutthroat hybrids and reduce the potential for an illegal fish introduction. Restocking the lake would likely have no impacts to Columbia spotted frogs, long toed salamanders or garter snakes as they currently co-exist with trout in the lake. Maintenance stocking would continue in Koessler Lake to maintain population viability and angling quality. Stocking would occur the July following the treatment and consist of 8,500 fish each year for three years. The population would be evaluated on year five post treatment to determine population viability and future stocking needs. The risk of reinvasion by downstream fish is unlikely due to the steep gradient of the stream below the lake.

George Lake is a 119.5-acre lake located in the Bob Marshall Wilderness at 7,115 feet above sea level. The maximum lake depth is 275 feet and lake volume is 13,475 acre-feet (Figure B28). The main surface water inputs to the lake include two perennial streams and four ephemeral streams on the north shore, and many seeps along the south shore. George Creek flows out of the lake for 0.17 mile where it flows over a waterfall. It continues for 3.75 miles to a 90-foot bedrock waterfall, which is about 0.25 mile above the confluence with Gordon Creek. Six unnamed streams enter from the south over the lower 4 miles of George Creek. Distance from this waterfall to George Lake is 3.92 miles.

There is no known trail access to George Lake. Hikers find access to the lake by National Forest access near Sunday Mountain in the East Fork of the Clearwater River. U of M genetics lab tests indicate the lake contains hybrid westslope cutthroat trout X Yellowstone cutthroat trout. MFWP records indicate the lake was stocked with generic cutthroat trout in 1939 and 1965, and with Yellowstone cutthroat trout in 1965 (Huston 1988). From 1988 through 2000 it was stocked eleven times with pure westslope cutthroat trout. An amphibian survey conducted in 2001 detected Columbia spotted frogs 0.18 mile to the northeast of the lake (Maxell 2002).

George Creek flows out of George Lake. In 2000 a small sample of fish were genetically tested from the creek near its mouth and found to be hybridized westslope cutthroat trout X Yellowstone cutthroat trout.

The management objective for this lake is to remove the hybrid trout from the lake and from the 3.92 mile of stream between the lake and the waterfall near its mouth. To achieve this objective, antimycin would be used because it is the quickest method for removal, it requires the least amount of material making transport to a remote location easier, and it naturally detoxifies with every 200 feet of downstream elevation drop making containment easier. The elevation differential between George Lake and the known bull trout population in Gordon Creek is approximately 1,875 feet. Approximately 1,300 feet of altitude drop occurs within the first 1 mile of stream that leaves the lake. Accessing this high gradient section would be difficult. Furthermore, it is unlikely that any fish reside in this section because it is so steep. For this reason, 2 recharge stations would be installed in the remaining section of stream to remove hybrid fish. A Forest Service foot trail provides access to George Creek to approximately 1 mile below the lake. Recharge stations would begin at this point and treat down to near its mouth, which is the lower boundary of the treatment area. The stream should be sufficiently detoxified by this point through natural processes. Furthermore, we would rely on fresh water input from three unnamed tributaries to George Creek to dilute the antimycin. Up to date flow measurements and on-site bioassays would be used to determine the level of natural detoxification. As a safeguard measure, caged fish would be placed in George Creek at the Gordon Creek confluence and if natural detoxification were not effective, potassium permanganate would be administered at the rate of 1ppm to detoxify the antimycin.

Because there is no trail to George Lake the 2,695 units (10,106 pounds) of antimycin necessary to treat the lake would be transported with 12 flights by a Bell OH58 helicopter. An additional 4 flights would be required to transport the equipment and personnel. Motorized rafts would be used to administer the antimycin. Five people would be needed to treat the lake, two to monitor recharge stations on the creek and another to monitor caged fish and administer potassium permanganate if necessary. Livestock would be used to deliver the personnel and materials for the stream work and would be staged from the Shaw Cabin. The treatment would require one day for transportation, one day for set up, one day to administer and two days for clean up then departure. Personnel and equipment would be flown out from the lake site when clean up is finished.

George Lake would be restocked with pure westslope cutthroat trout from the Washoe Park State Fish Hatchery in Anaconda. MFWP records indicate it receives an estimated 105 (60-180) angler days per year. It's annual statewide ranking is number 923 out of 1,529 fisheries in the state (Table 12). Restocking genetically pure westslope cutthroat would maintain angling opportunity at George Lake, provide a source of pure fish to repopulate downstream, genetically dilute any possible remaining westslope X Yellowstone cutthroat hybrids and reduce the potential for an illegal fish introduction. Restocking the lake would likely have no impacts to Columbia spotted frogs known to occur in the vicinity, as they currently co-exist with trout in the lake. Maintenance stocking would continue in George Lake to maintain population viability and angling quality. Stocking would occur the July following the treatment and involve 11,400 fish each year for 3 years. The population would be evaluated on year five-post treatment to determine population viability and future stocking needs. The risk of reinvasion by downstream fish is non-existent due to the steep waterfall immediately downstream of the lake.

<u>Pyramid Lake</u> is a 8.9-acre lake located in the Bob Marshall Wilderness at 6,927 feet above sea level. The maximum lake depth is 37 feet and lake volume is 191 acre-feet (Figure B29). The main surface water input to the lake is located on the southwest shore. Pyramid Creek flows out of the lake for 1.84 miles until it reaches the confluence with Young Creek. This section of stream is at 11% gradient and is reported to frequently go dry. Youngs Creek flows for 1.43 miles where it meets with Devine Creek, then for 1.08 miles until it reaches Ross Creek, then 1.69 miles until it reaches Jenny Creek. The area between Spruce and Jenny Creeks is the uppermost distribution of bull trout in the Young Creek drainage. The distance from this point to Pyramid Lake is approximately 5.2 miles.

Pyramid Lake can be accessed by a 2.7-mile long trail beginning at the Pyramid Pass trailhead. U of M genetics lab tests indicate the lake contains hybrid westslope cutthroat trout X Yellowstone cutthroat trout and hybrid westslope cutthroat trout X rainbow trout. MFWP records indicate the lake was stocked with Yellowstone cutthroat trout in 1950 (Huston 1988). From 1988 through 1994 it was stocked seven times with pure westslope cutthroat trout. An amphibian survey conducted in 2001 did not detect any amphibians in the area (Maxell 2002).

The management objective for this lake is to remove the hybrid trout from the lake, from the small pond downstream of the lake and from the 3.3 miles of stream between the lake and the Youngs/ Devine Creek confluence. To achieve this objective, antimycin would be used because it is the quickest method for removal, it requires the least amount of material making transport to a remote location easier, and it naturally detoxifies with every 200 feet of downstream elevation drop making containment easier. The stream that flows out of Pyramid Lake often runs dry in the fall of the year. If it is flowing, the stream down to Devine Creek would be treated, otherwise, the lower boundary of the project would be where the stream goes dry. The elevation differential between Pyramid Lake and Devine Creek confluence is approximately 1,242 feet, which, if the stream is flowing, would require installing approximately 5 recharge stations to maintain antimycin lethality in this section of stream. We would rely on fresh water input from Devine Creek, Ross Creek and Spruce Creek to dilute the antimycin before it reaches the bull trout population. Forest Service trail 283 parallels upper Youngs Creek making access easier. Up to date flow measurements and on-site bioassays would be used to determine the level of natural detoxification present during treatment. As a safeguard measure, caged fish would be placed in Youngs Creek downstream of Devine Creek to measure toxicity of antimycin at this point. If natural detoxification were not effective, potassium permanganate would be administered to detoxify the antimycin.

Transporting the estimated 38 units (143 pounds) of antimycin needed to treat the lake would require 1 mule load. A camp would be set at Pyramid Lake to conduct the treatment. Approximately 5 people would be needed to treat the lake, 5 for the stream, and one to monitor caged fish in Youngs Creek and administer potassium permanganate if needed. The materials, rafts, motors and camp would require approximately six mule loads. Two outboard motors would be required to administer the antimycin in a timely manner and to mix the compound with lake water. Pumps would be used to distribute the compound at deeper depths. All materials, equipment and personnel could be transported to the site in one day and set up would begin. Thereafter, the treatment would require one day, two days for clean up and leave.

Pyramid Lake would be restocked with pure westslope cutthroat trout from the Washoe Park State Fish Hatchery in Anaconda. MFWP records indicate it receives an estimated 57 (25-83) angler days per year. It's annual statewide ranking is number 1,175 out of 1,529 fisheries in the state. Restocking genetically pure westslope cutthroat would maintain angling opportunity at Pyramid Lake, provide a source of pure fish to repopulate downstream, genetically dilute any possible westslope X Yellowstone cutthroat and/or rainbow hybrids, and reduce the potential for an illegal fish introduction. Maintenance stocking would continue in Pyramid Lake to maintain population viability and angling quality. Stocking would occur the July following the treatment and involve 1,000 fish each year for three years. The population would be evaluated on year five post treatment to determine population viability and determine future stocking needs. The risk of reinvasion by downstream fish into Pyramid Lake is low due to the high gradient of the stream below the lake and the fact that the stream frequently flows underground.

Summary and timing of lake treatments

The information in the previous section provides, estimates, technical and logistical issues associated with the treatment of each lake. For ease in reference, some of this information has been summarized in Table 13.

MFWP will attempt to conduct lake treatments at the rate of 2 per year until the project is complete. When determining the sequence of these treatments MFWP considered factors like lake size, which would influence complexity and cost, angling popularity, and proximity to other fisheries, among others. Because there will be a temporary loss of angling opportunity following the treatment and during the re-establishment of a westslope cutthroat trout population in each lake, treatments will be staggered spatially to offset this burden to anglers. In addition catchable fish would be restocked into some lakes, as previously mentioned, to restore the fishery as quickly as possible. The estimated time frame for completing this project is within 10 years (Table 14). Table 14 provides a tentative schedule for lake treatments and could likely be modified to accommodate special needs that would benefit the success of this project. For example, if no outflow is present on a particular lake, and containment would be made easier by not having to detoxify the outflow stream, it may be necessary to prioritize the timing of some lake treatments. Other factors like environmental changes, trail closure, fire, etc. will likely influence the schedule of activities and require reasonable modification.

Table 13. Summary of fish removal methods recommended for each lake and associated stream, transport method(s), number of fish restocked to establish a population, and amphibian status.

Lake	Size (acres)	Antimycin (units)	Antimycin (pounds)	Prenfish (gallons)	Prenfish (pounds)	Transport method	Number of loads	Stream miles treated	# fish to restock	Amphibian status
Wildcat	40	404	1,515	---	---	helicopter	2	0.90	3,900 x 3	NA
Clayton	62	---	---	2,316	22,697	SEAT/heli	4/4	4.52	5,800 x 3	Spotted frog, salamander
Blackfoot	16.5	---	---	68	667	helicopter	1	5.76	1,600 x 3	Spotted frog, salamander
Black	49.1	---	---	1,469	14,396	SEAT/heli	2/6	6.09	4,900 x 3	Spotted frog, salamander w/in 0.6 mile
Handkerchief	51.3	159	596	---	---	truck	1	1.33	As needed	Spotted frog
Upper Three Eagles	10.8	---	---	162	1,588	helicopter	2	0.28	900 x 3	Spotted frog, salamander w/in 0.58 mile
Lower Three Eagles	8.7	---	---	85	816	helicopter	1	2.23	900 x 3	Spotted frog, salamander w/in 0.83 mile
Pilgrim	29.9	---	---	842	8,252	SEAT/heli	1/4	3.27	3,000 x 3	Salamander w/in 0.69 mile
Lower Bighawk	27.3	---	---	204	1,999	helicopter	3	2.97	2,700 x 3	Spotted frog, salamander w/in 1.37 miles
Margaret	46.5	---	---	654	6,409	SEAT/heli	2/2	3.00	4,700 x 3	NA
Sunburst	148.5	2,537	9,513	---	---	livestock	55	6.10	14,800 x 3	Garter snake
Woodward	65	451	1,691	---	---	livestock	10	2.96	6,500 x 3	Spotted frog
Necklace (4)	42.8	64	240	---	---	livestock	2	2.10	1,400 x 3	Spotted frog, salamander
Lena	74.2	507	1,900	---	---	livestock	11	4.25	7,400 x 3	Spotted frog
Lick	19	28	105	---	---	helicopter	1	3.70	1,900 x 3	Spotted frog, garter snake
Koessler	86.5	1,146	4,298	---	---	livestock	25	0.10	8,500 x 3	Spotted frog, salamander, garter snake
George	119.5	2,695	10,106	---	---	helicopter	12	3.92	11,400 x 3	Spotted frog
Pyramid	8.9	38	143	---	---	livestock	1	3.30	1,000 x 3	NA

Table 14. Tentative sequence of lake treatments.

Lake	year	Land designation
Blackfoot	1	Hiking Area
Pyramid	1	Wilderness
Black	2	Hiking Area
Lick	2	Wilderness
Handkerchief	3	National Forest
Lena	3	Wilderness
Clayton	4	Hiking Area
Necklace (4)	4	Wilderness
Pilgrim	5	Hiking Area
George	5	Wilderness
Wildcat	6	Hiking Area
Koessler	6	Wilderness
Three Eagles (2)	7	Hiking Area
Margaret	7	National Forest
Lower Bighawk	8	Hiking Area
Woodward	8	Wilderness
Sunburst	9	Wilderness

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APPENDIX A

Amphibian survey results
and food habits of westslope cutthroat trout
from lakes in the Flathead Basin

Table A1. Presence, species composition and/or nearest population of amphibians in lakes proposed for hybrid trout removal, South Fork Flathead River drainage, 1999-2001 (from Maxell 2001 and USFS 1999 surveys).

lake	*Amphibians detected*	*Species*	*Distance to nearest detected amphibian*
Wildcat	No	---	---
Clayton	Yes	Columbia spotted frog, Long toed salamander	
Blackfoot	Yes	Columbia spotted frog, Long toed salamander	
Black	No	Columbia spotted frog, Long toed salamander	Six lakes w/in 0.6 mile
Handkerchief	Yes	Columbia spotted frog	
Upper 3 Eagles	No	Columbia spotted frog, Long toed salamander	3 lakes w/in 0.58 mile
Lower 3 Eagles	No	Columbia spotted frog, Long toed salamander	3 lakes w/in 0.83 mile
Pilgrim	No	Long toed salamander	1 lake 0.69 mile
Lower Bighawk	No	Columbia spotted frog, Long toed salamander	3 lakes 1.37 mile
Margaret	No	---	---
Sunburst	Yes	Garter snake	
Woodward	Yes	Columbia spotted frog	
Necklace chain	Yes	Columbia spotted frog, Long toed salamander	
Lena	Yes	Columbia spotted frog	
Lick*	Yes	Columbia spotted frog, Garter snake	
Koessler	Yes	Columbia spotted frog, Long toed salamander, Garter snake	
George	Yes	Columbia spotted frog	
Pyramid	No	---	---

* 1999 USFS survey

Table A2. Temporal status of amphibian populations in 21waters treated with rotenone in the Kalispell area, 2002.

Lake/stream	*Year(s) treated with rotenone*	*June*	*July*	*August*	*Sept*
Trout Lake	1968		CSF (9 adult, ~30 tadpole)	CSF (8 adult, 11 juv, 10 tads) LTS (1 larva)	
Rogers Lake	1957, 1967, 1993	CSF (9 adult, 7 tadpole) WT (200+ tadpole)	CSF (5 juvenile) PTF (9 juvenile) LTS (5 larva)		CSF (37 adult) PTF (6 juvenile) LTS (1 adult) WT (11 juvenile)
Murray Lake	1997	CSF (9 adult)	CSF (5 adult, 20 juvenile) PTF (2 juvenile)		None
Dollar Lake	1997	CSF (3 juvenile)	CSF (5 adult, 1 tadpole)		None
Bootjack Lake	1961, 1996	CSF (7 adult)	CSF (11 adult, 3 tadpole) LTS (4 larva)		CSF (20 adult, 14 juvenile)
Lion Lake	1992	None		CSF (17 juvenile)	CSF (13 adult)
Hubbart Reservoir	1958, 1973, 1987, 1999	CSF (2 adult) WT (3 adult, <1000 tadpole, 4 egg sets)		CSF (2 adult) LTS (1 larva) WT (~1-200,000 juvenile)	CSF (1 adult) WT (4 juvenile)
Hidden Lakes (2)	1958, 1973, 1999	CSF (15 adult) PTF (4 adult) WT (1 adult)		CSF (17 adult, 10 juv, 8 tads) PTF (4 juvenile) LTS (11 larvae) WT (1 adult)	CSF (1 adult, 12 juvenile) PTF (4 juvenile)
Elliot Pond	1991	None	None		None
L. McGregor Lake	1961, 1998	CSF (2 adult)	CSF (4 adult, 9 juv, 3 tadpole) LTS (21 larva)		CSF (11 adult, 5 juvenile)
Tom Tom Lake	2000		CSF (1 adult, 115 juvenile) LTS (2 larvae, ~40 eggs) TF (5 tadpole)		CSF (9 adult, 51 juv, 3 tadpole) LTS (11 larva)
Jewel Lakes (4)	1986		CSF (76 adult, 103 juv, 110 tadpole) TF (1 adult)		CSF (12 adult, 83 juv, 176 tadpole)
Whale Lake	2000		LTS (21 larva)		LTS (13 larva) TF (1 adult)
Devine Lake	1994		CSF (1 adult, 50 tadpole)		
Elliot Creek	1991	None	None		None
Taylor Spring ck	1993	CSF (6 adult)	CSF (6 adult, 1 juvenile)	CSF (14 adult)	
L. Bitterroot R	1973, 1999	CSF (41 adult, ~500 tadpole) LTS (4 larva) WT (1 adult)		CSF (34 adult, 21 juv,33 tads) LTS (121 larva)	CSF (33 adult, 177 juvenile) LTS (1 adult) WT (1 adult, ~750 juvenile)

CSF=Columbia spotted frog, WT=Western toad, PTF=Pacific tree frog, TF=tailed frog, LTS=Long toed salamander

Table A3. Observations of amphibians during electrofishing surveys in South Fork Flathead streams. Data collected incidental to fish population surveys and is not considered qualitative or quantitative.

year	*Wounded buck*	*Tiger*	*Riverside*	*Quintonkon*	*North Logan*	*Murray*	*McInernie*	*Margaret*	*Lost Mare*	*Hungry Horse*	*Felix*	*Emery*	*Harris*	*Wheeler*
1987	---	NR	tailed frog	tailed frog	---	---	---	tailed frog	tailed frog	tailed frog	---	---	---	---
1988	---	NR	---	---	NR	---	NR	NR	NR	NR	NR	NR	NR	---
1989	---	NR	---	---	---	---	---	NR	NR	NR	---	NR	---	---
1990	---	NR	---	---	---	---	tailed frog	NR	NR	tailed frog	NR	---	NR	---
1991	---	---	---	---	---	---	NR	---	---	NR	tailed frog	---	---	---
1992	---	---	NR	---	NR	NR	NR	NR	NR	NR	NR	---	NR	---
1993	---	---	---	---	---	NR	NR	---	---	NR	NR	---	NR	---
1994	---	---	---	---	---	tailed & spotted frog, western toad	---	---	---	tailed frog	NR	---	NR	---
1995	NR	---	---	---	---	spotted frog, tailed frog	---	NR	---	tailed frog	tailed frog	---	---	---
1996	tailed frog	---	---	---	tailed frog	tailed frog	tailed frog	tailed frog	---	tailed frog	NR	---	tailed frog	---
1997	NR	tailed frog	tailed frog	---	tailed frog	NR	NR	tailed frog	tailed frog	---	---	tailed frog	NR	---
1998	tailed frog	tailed frog	NR	---	NR	NR	NR	NR	tailed frog	tailed frog	tailed frog	NR	NR	---
1999	NR	tailed frog	NR	---	tailed frog	tailed frog, spotted frog	tailed frog	tailed frog	NR	tailed frog	LT salaman	tailed frog	NR	---
2000	tailed frog	NR	NR	---	NR	NR	NR	NR	NR	tailed frog	NR	---	NR	---
2001	tailed frog	NR	---	---	---	---	---	tailed frog	---	tailed frog	---	tailed frog	---	tailed frog
2002	NR	tailed frog	---	---	---	---	---	tailed frog	---	tailed frog	---	tailed frog	---	tailed frog

--- not sampled
NR no record of amphibians during sampling

Table A4. Stomach contents of westslope cutthroat trout (n=89) sampled during periods of high amphibian tadpole abundance in four lakes in the Flathead basin, Montana, 2002.

		JULY					AUGUST						SEPTEMBER	
lake	Trout	Moose				Trout	Moose	Lupine	Rogers				Lupine	Rogers
Plecoptera													present	
Ephmemeroptera	present					present	present	present	present				present	
Trichoptera	present	present				present	present		present				present	
Diptera	present	present				present	present	present	present				present	
Odonata	present					present		present					present	
Coleoptera	present	present				present	present		present				present	
Mollusca	present					present	present	present					present	
Crustacea	present	present					present	present	present				present	present
Hirudinea	present	present				present	present	present						
Zygoptera									present					
Belostomatidae		present				present								
Hemiptera									present				present	present
Zooplankton						present	present	present	present				present	present
Terrest. insect	present					present	present	present	present				present	
Arachnid	present	present												
Fish							present							

APPENDIX B

Bathymetric maps of project lakes in the South Fork Flathead River drainage

Figure B1. Bathymetric map of Wildcat Lake.

Figure B2. Bathymetric map of Clayton Lake.

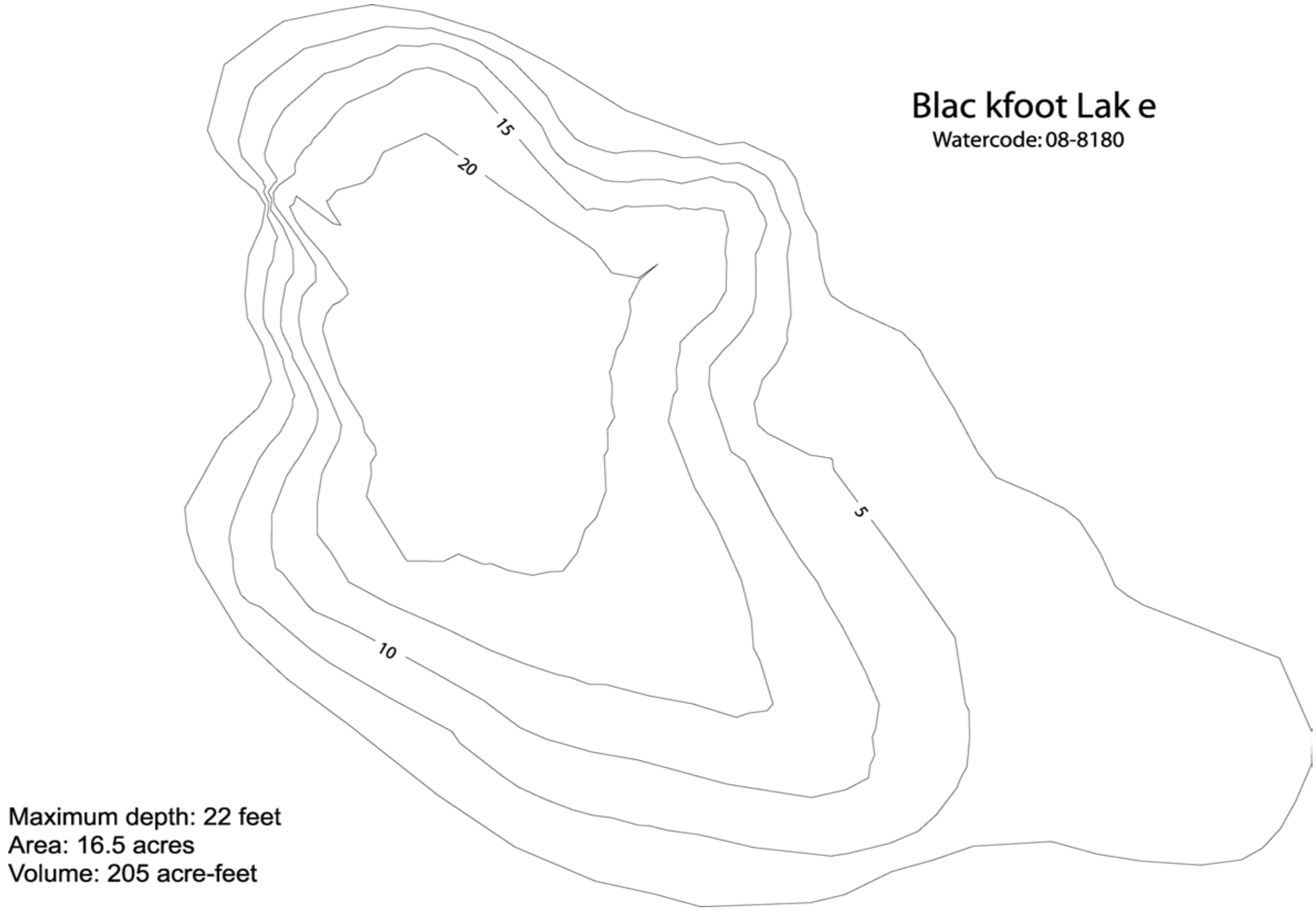

Figure B3. Bathymetric map of Blackfoot Lake.

Figure B4. Bathymetric map of Black Lake.

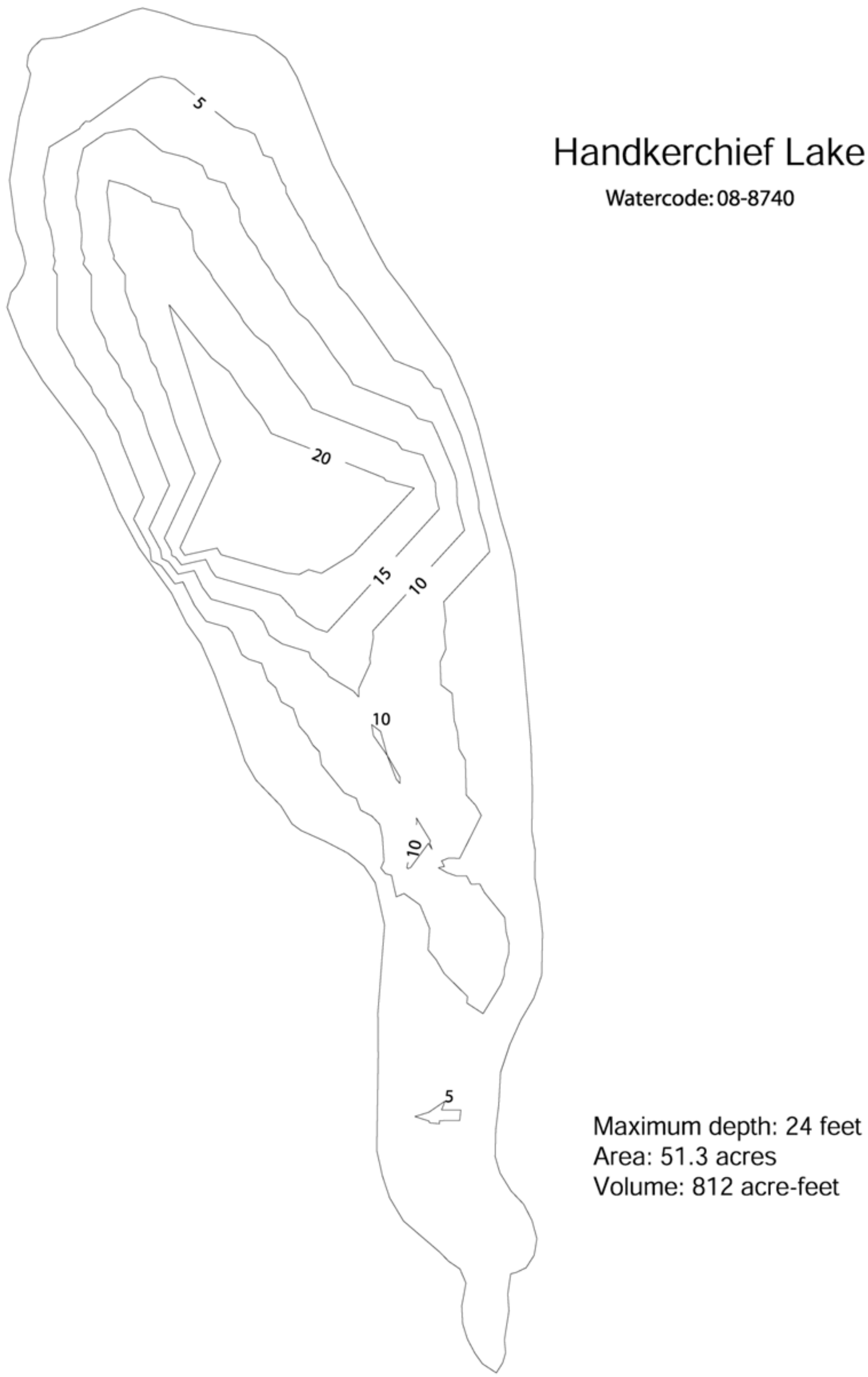

Figure B5. Bathymetric map of Handkerchief Lake.

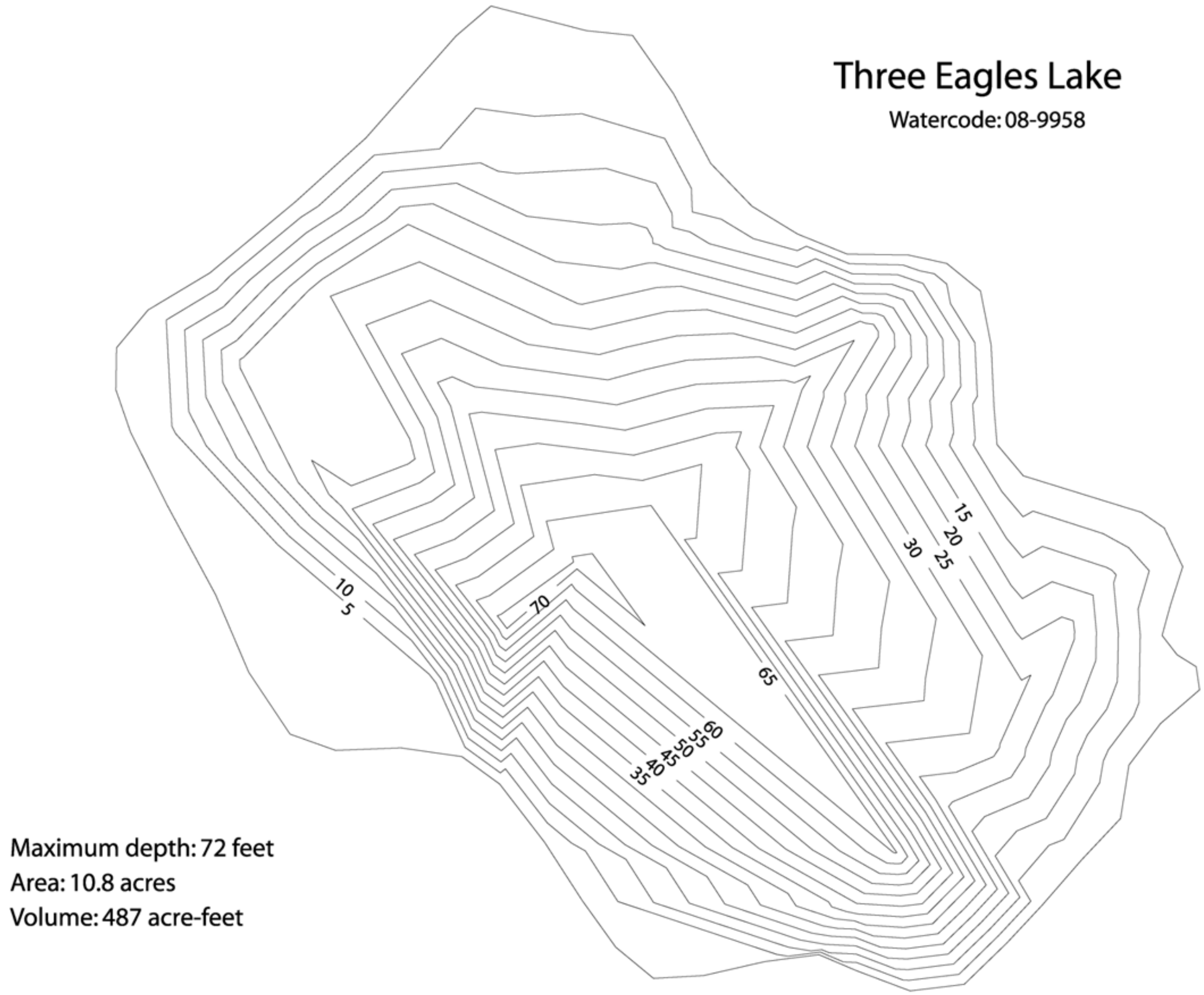

Figure B6. Bathymetric map of Upper Three Eagles Lake

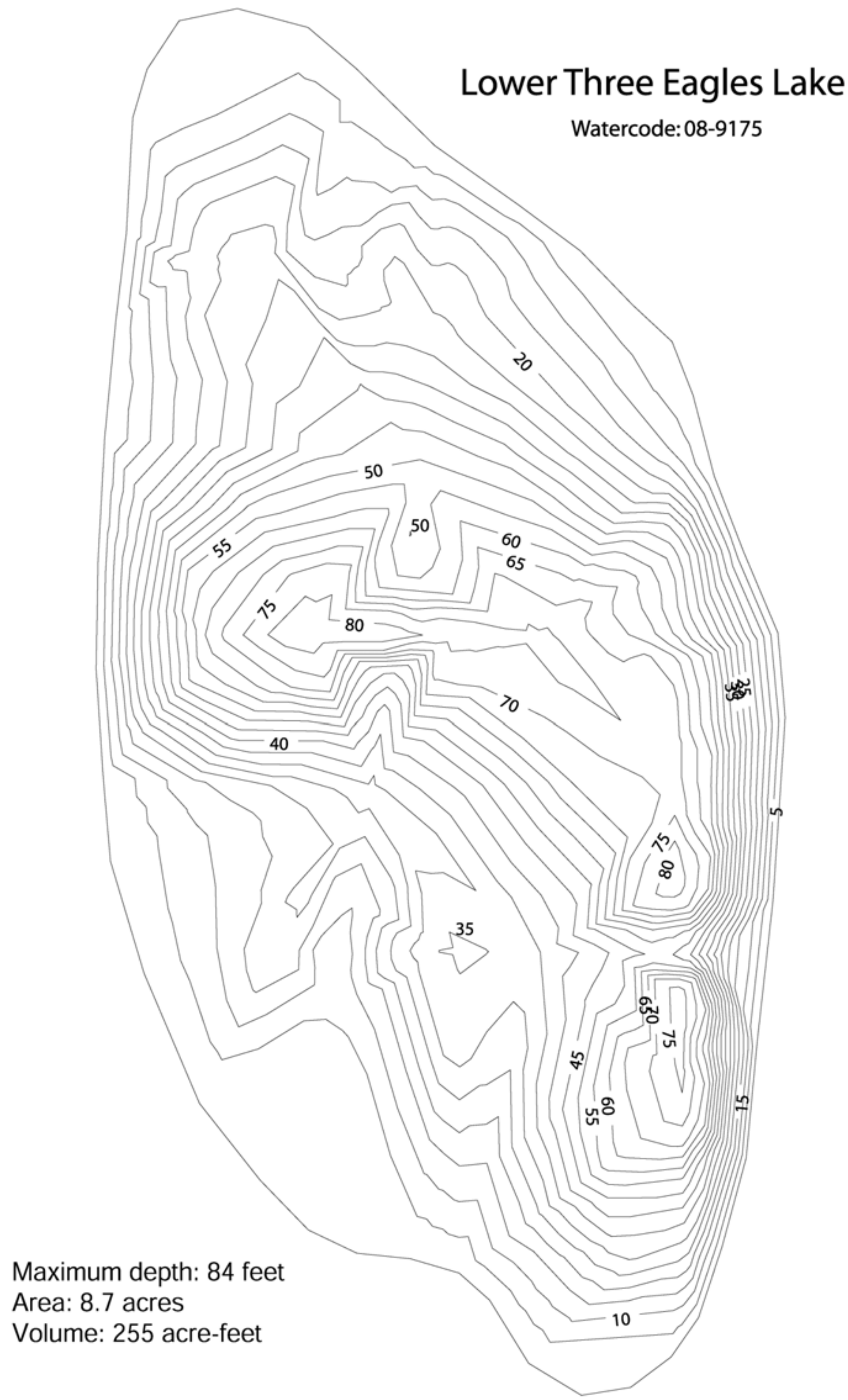

Figure B7. Bathymetric map of Lower Three Eagles Lake.

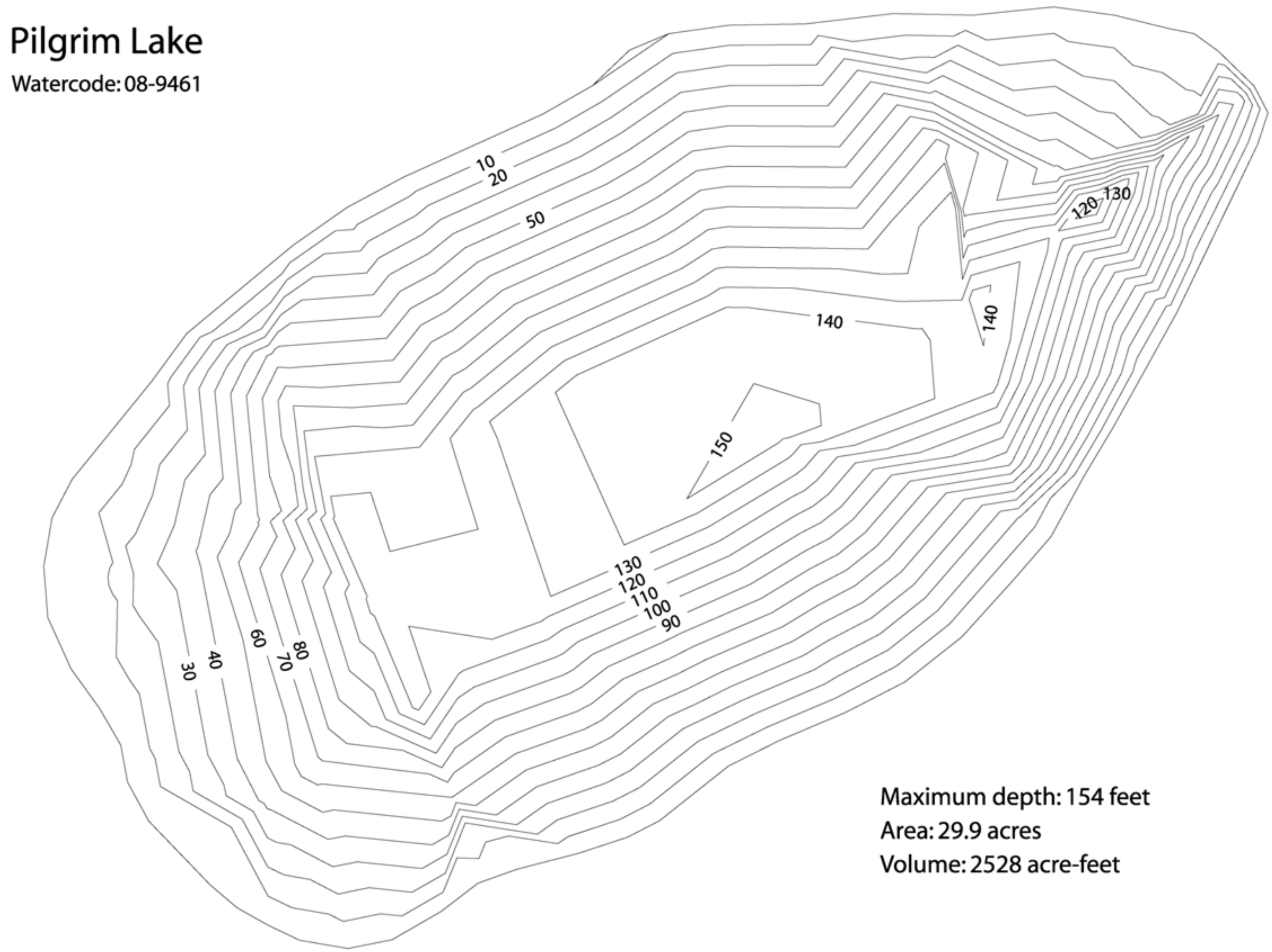

Figure B8. Bathymetric map of Pilgrim Lake.

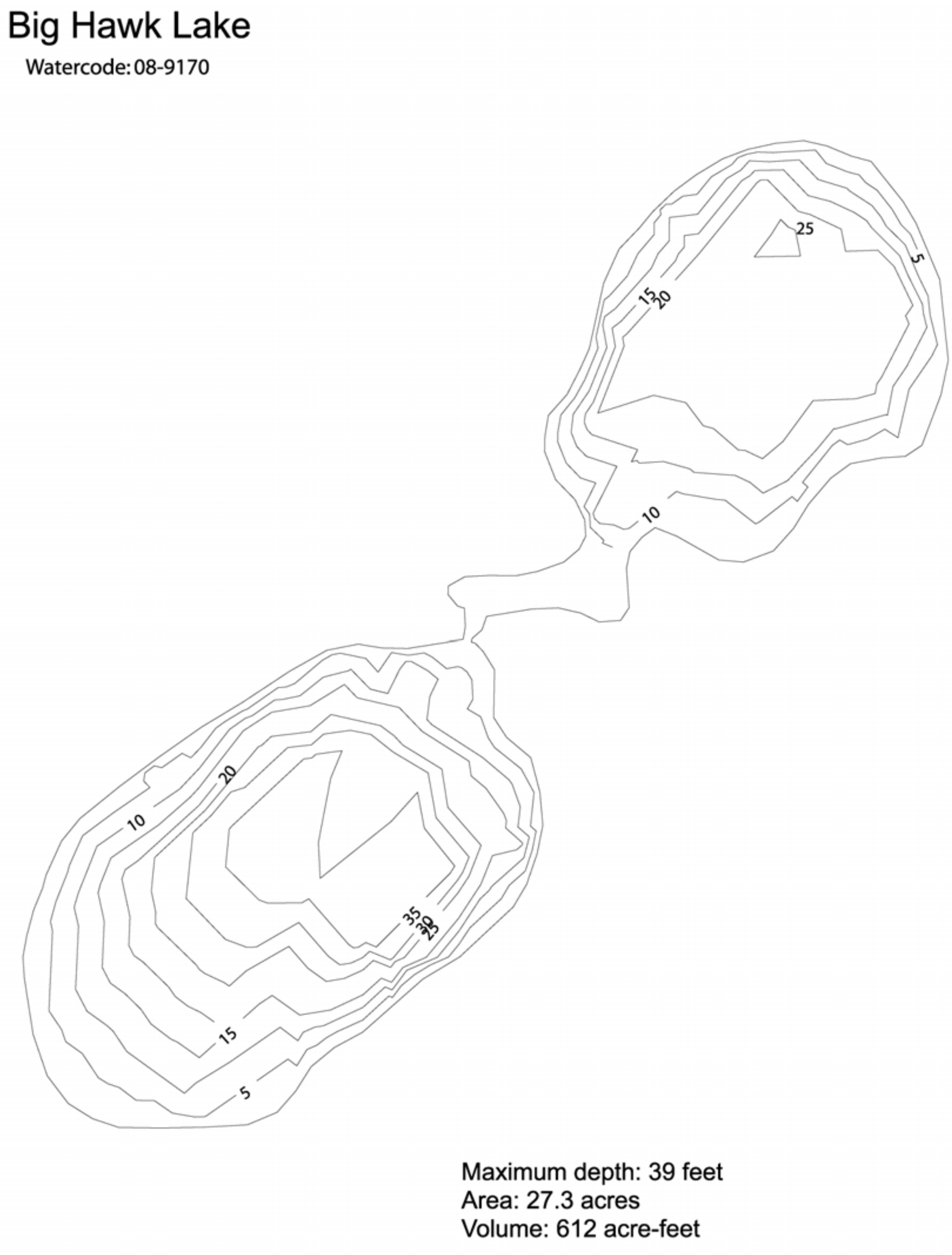

Figure B9. Bathymetric map of Lower Bighawk Lake.

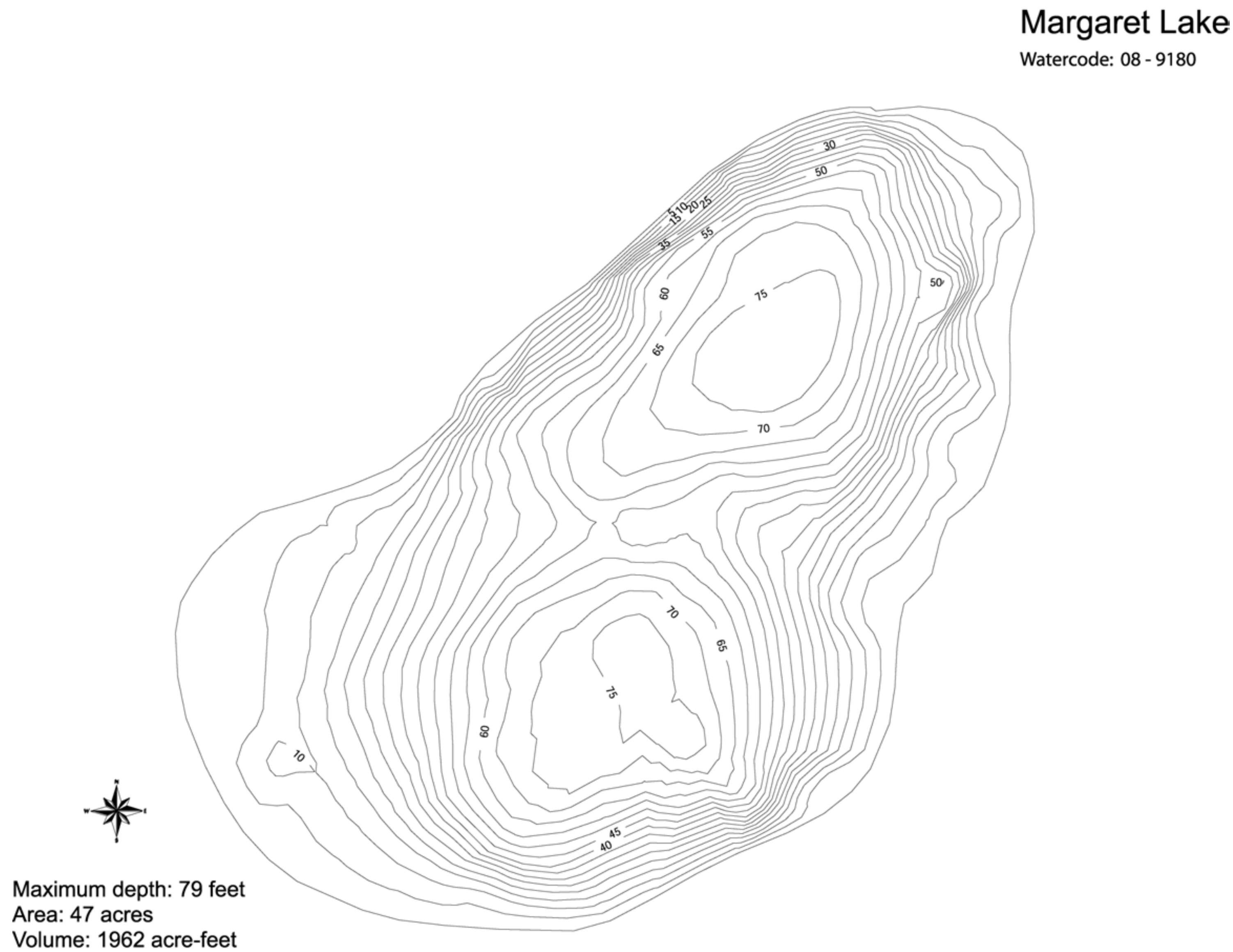

Figure B10. Bathymetric map of Margaret Lake.

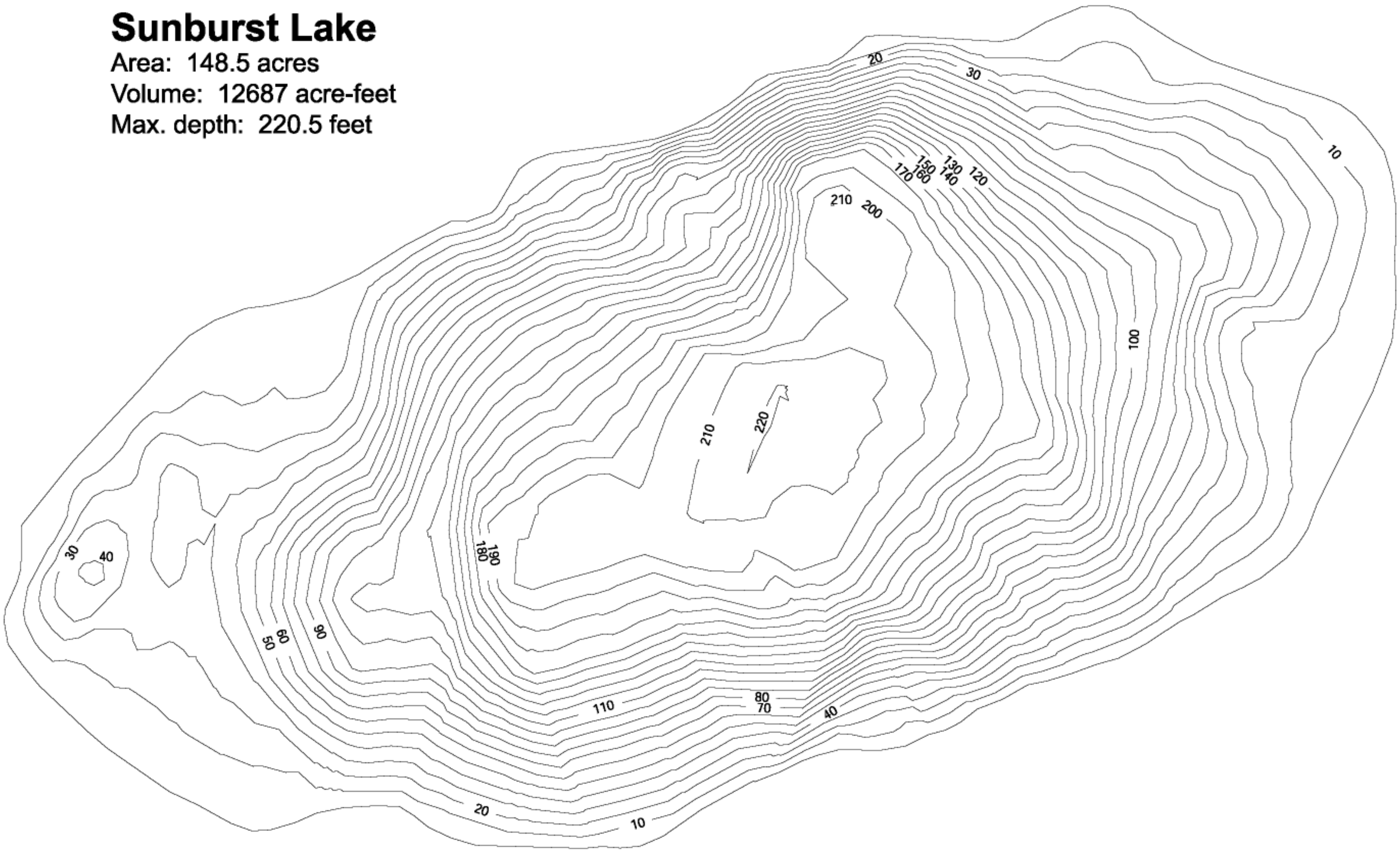

Figure B11. Bathymetric map of Sunburst Lake.

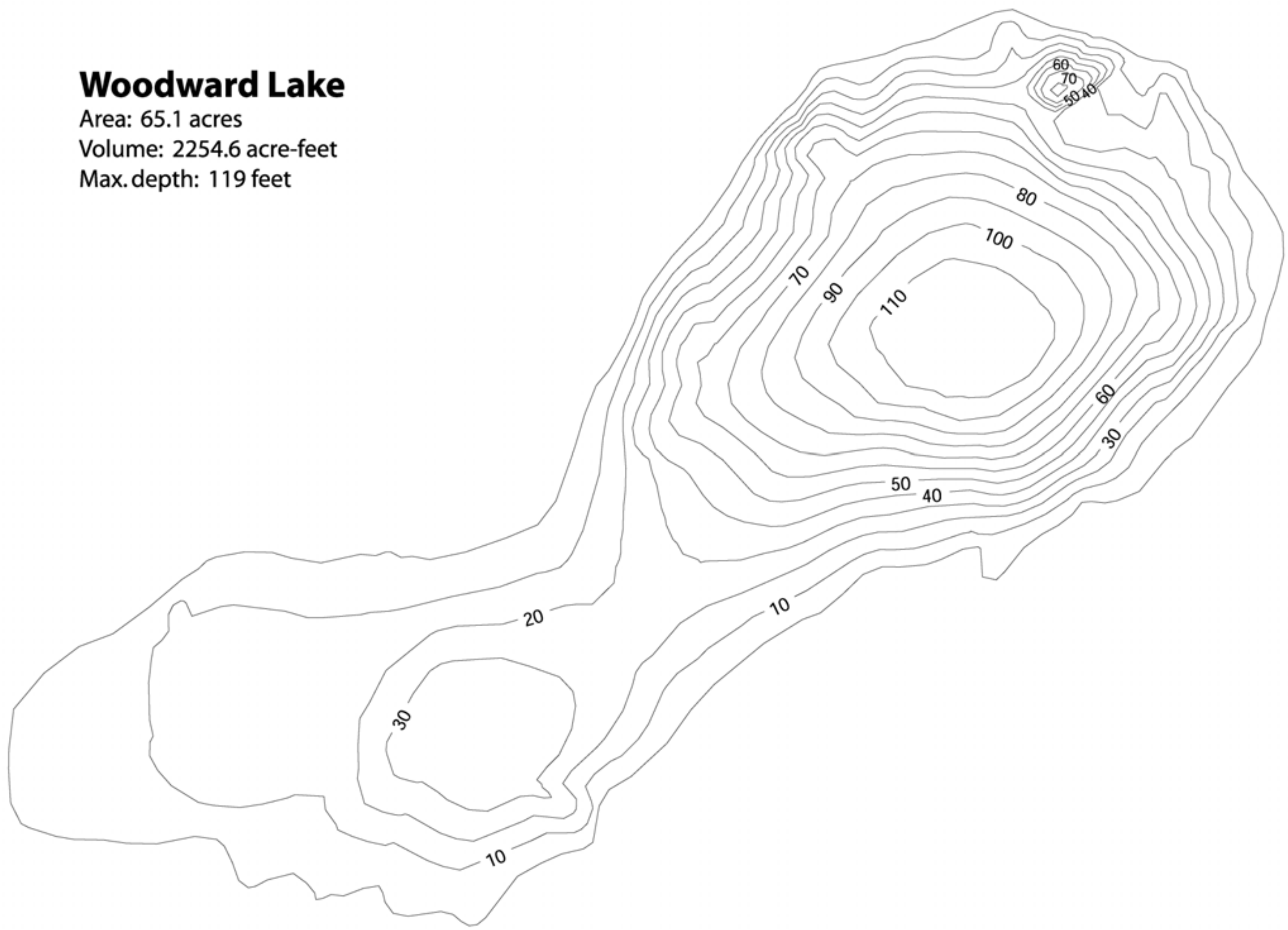

Figure B12. Bathymetric map of Woodward Lake.

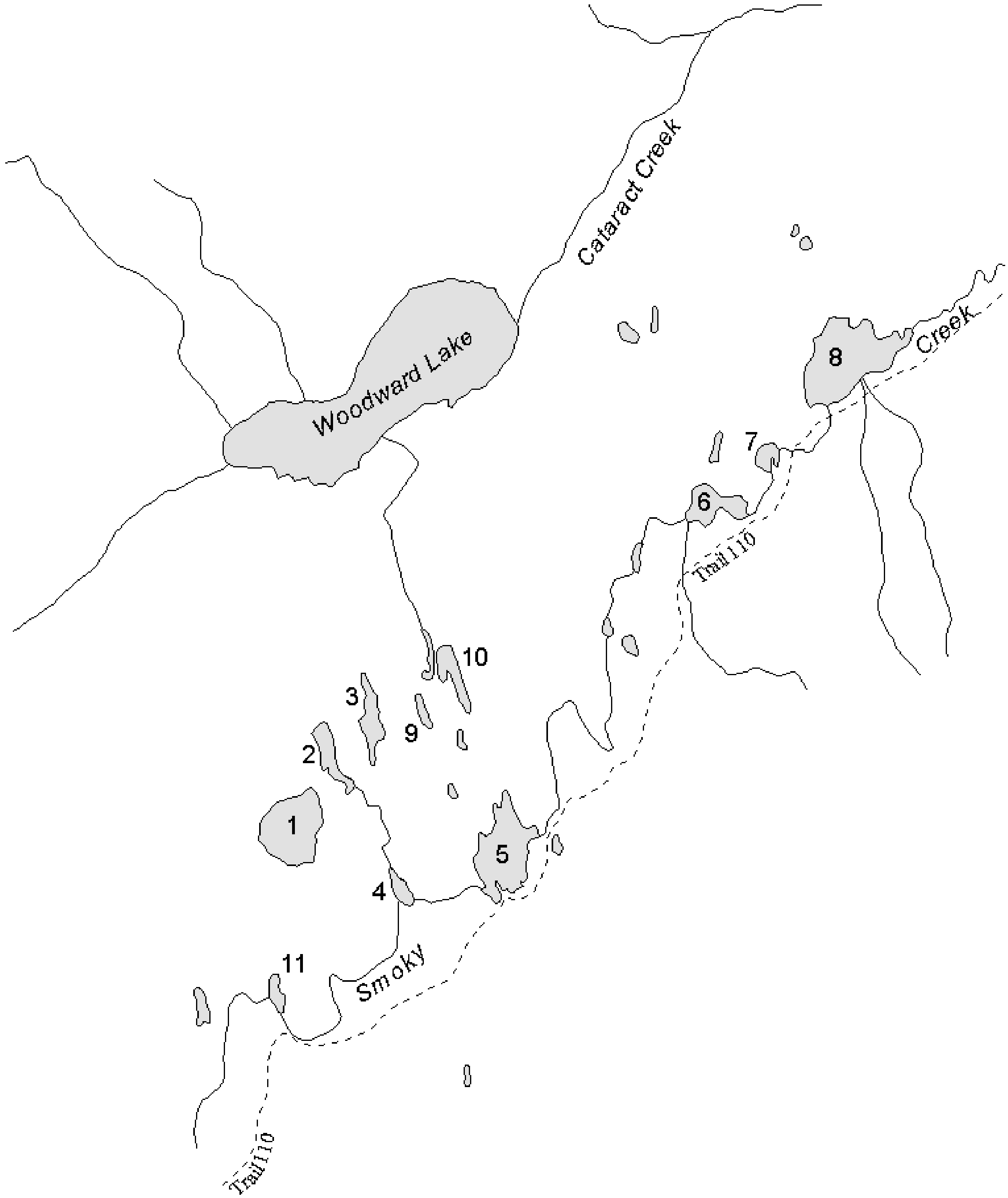

Figure B13. Index map of Necklace Lakes.

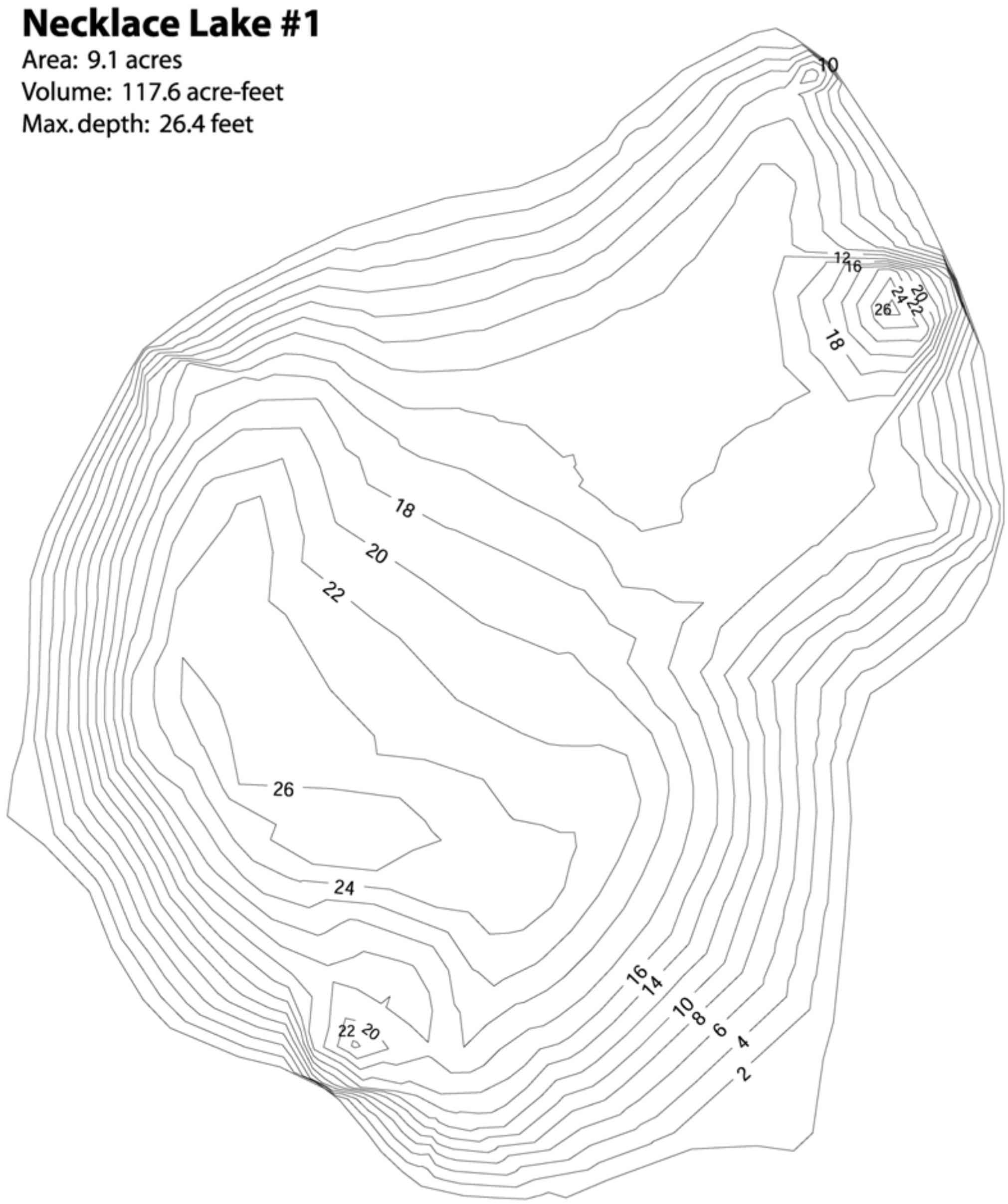

Figure B14. Bathymetric map of Necklace Lake #1.

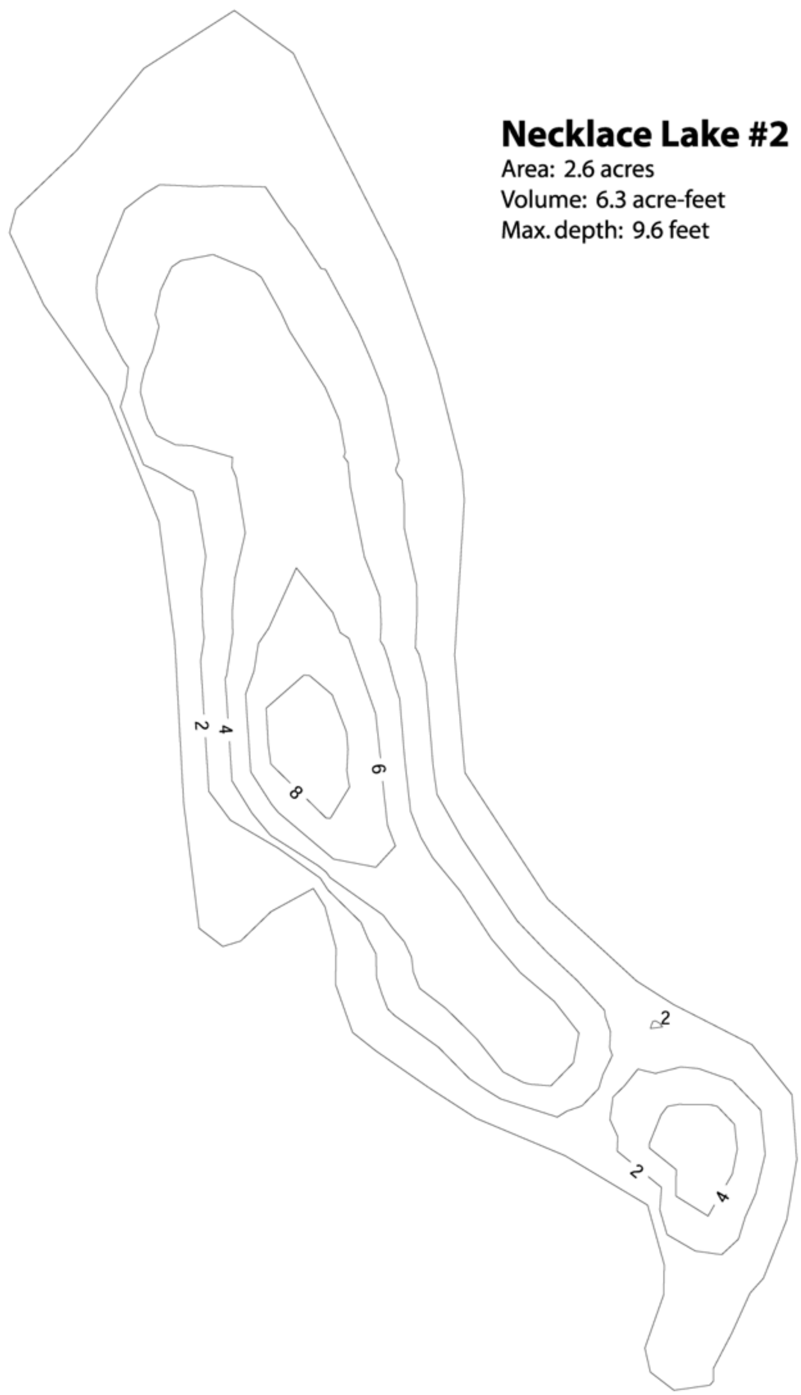

Figure B15. Bathymetric map of Necklace Lake #2.

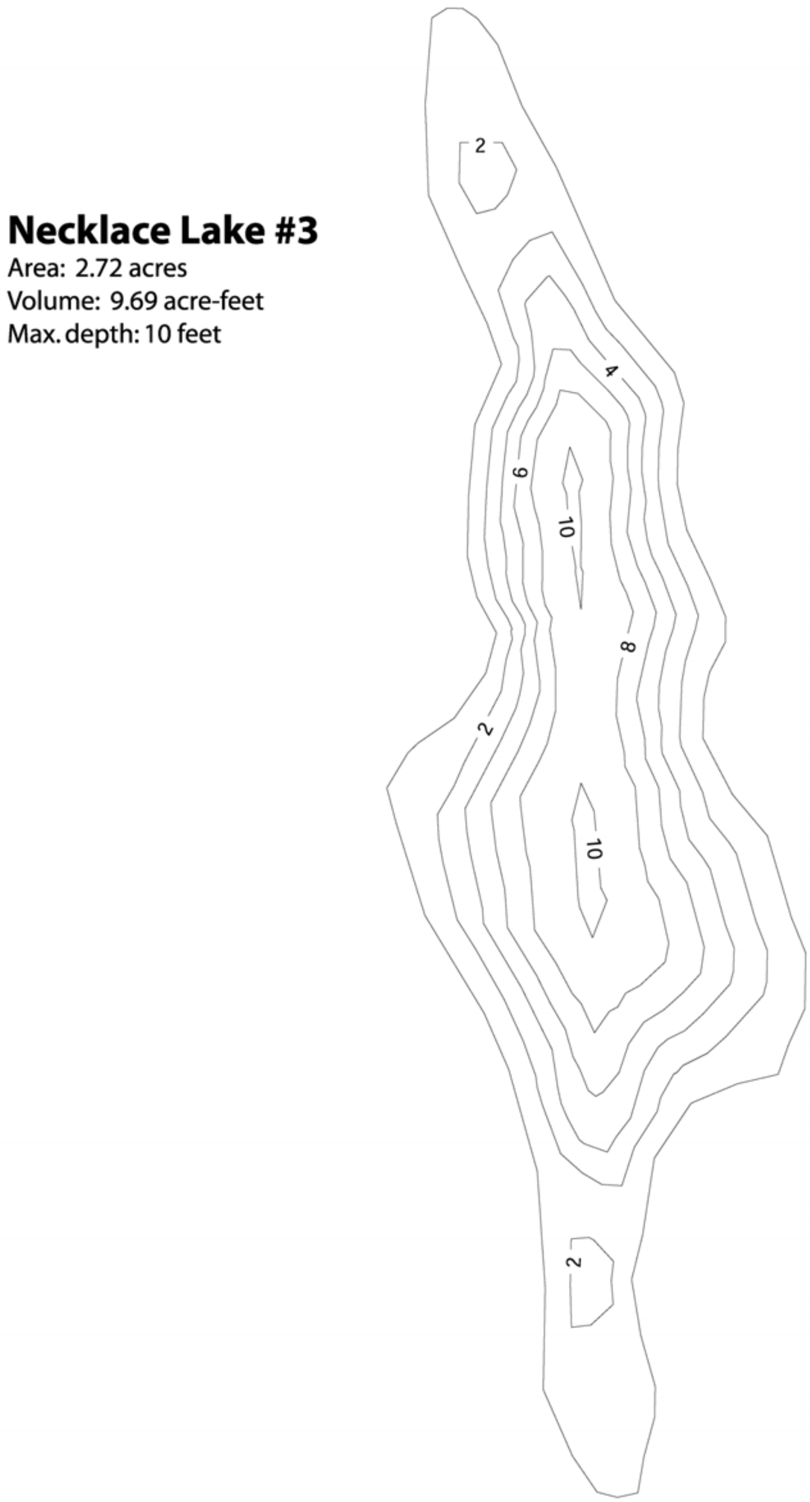

Figure B16. Bathymetric map of Necklace Lake #3.

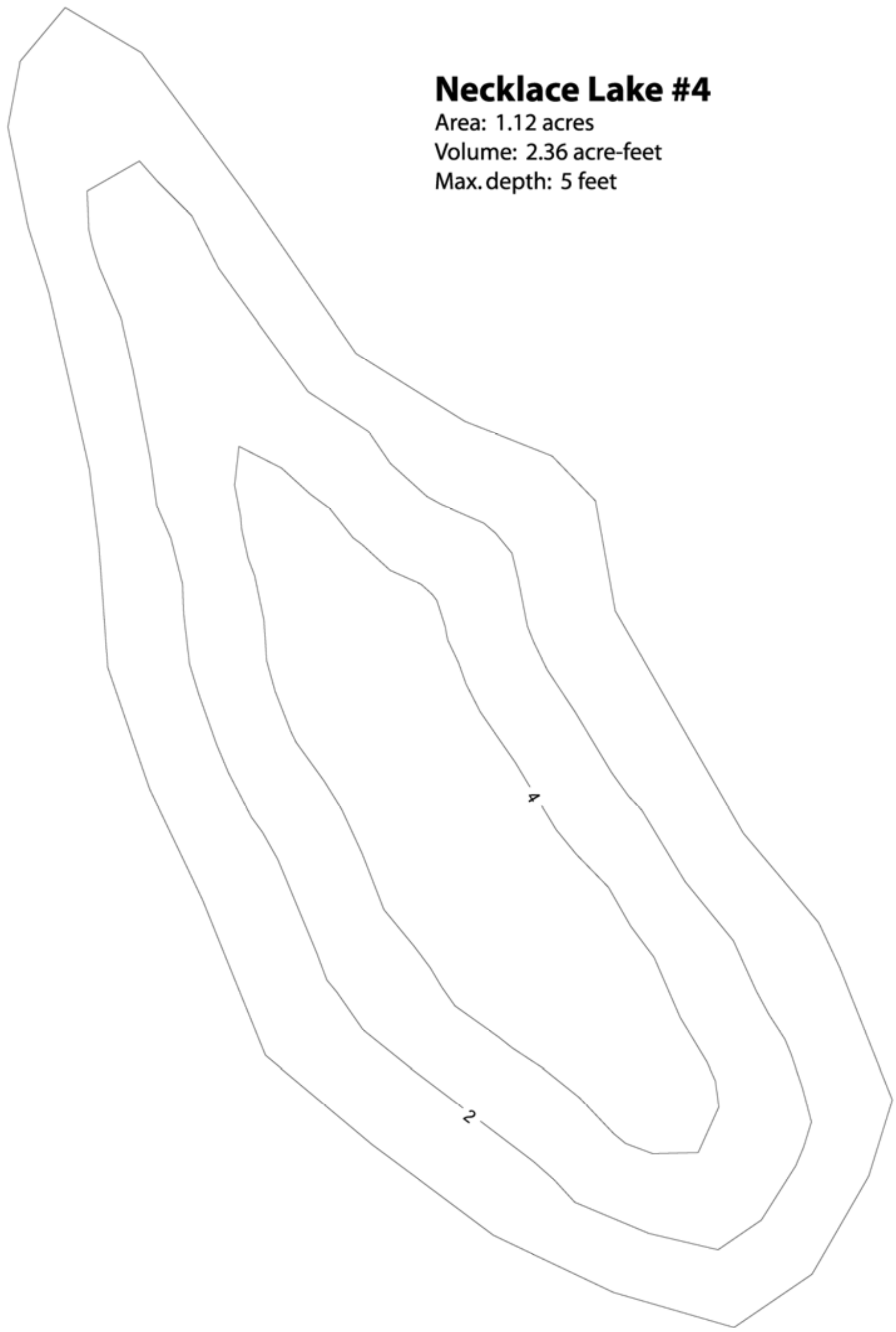

Figure B17. Bathymetric map of Necklace Lake #4.

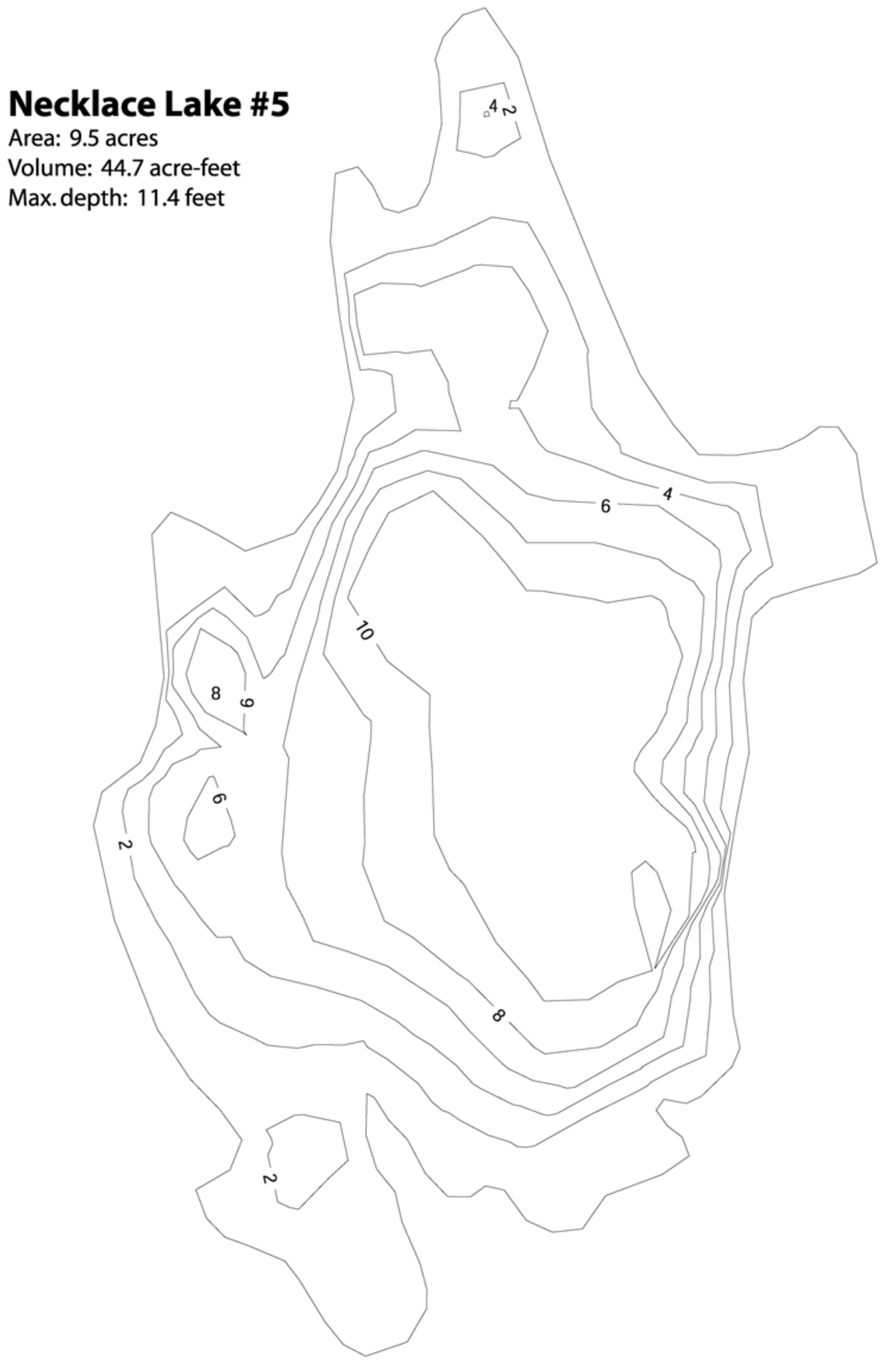

Figure B18. Bathymetric map of Necklace Lake #5.

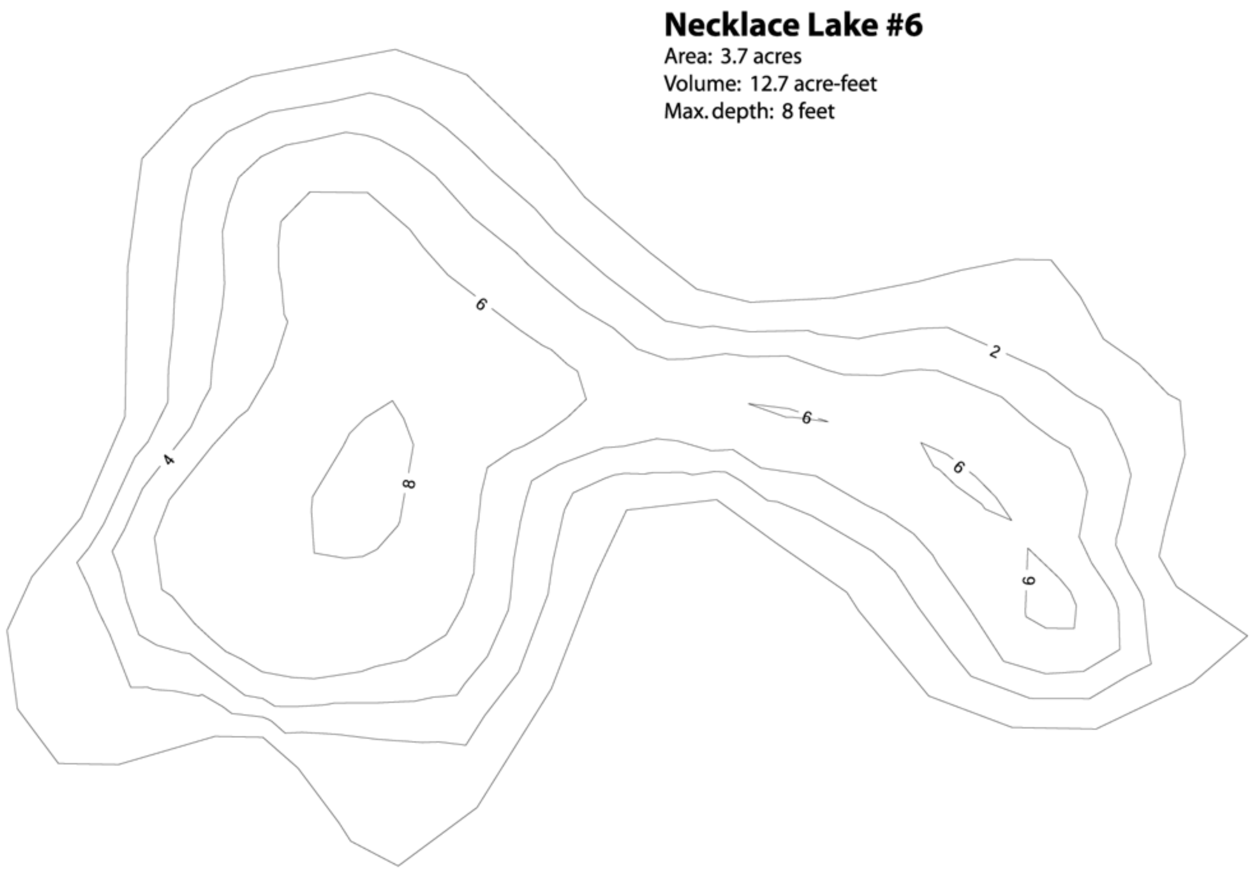

Figure B19. Bathymetric map of Necklace Lake #6.

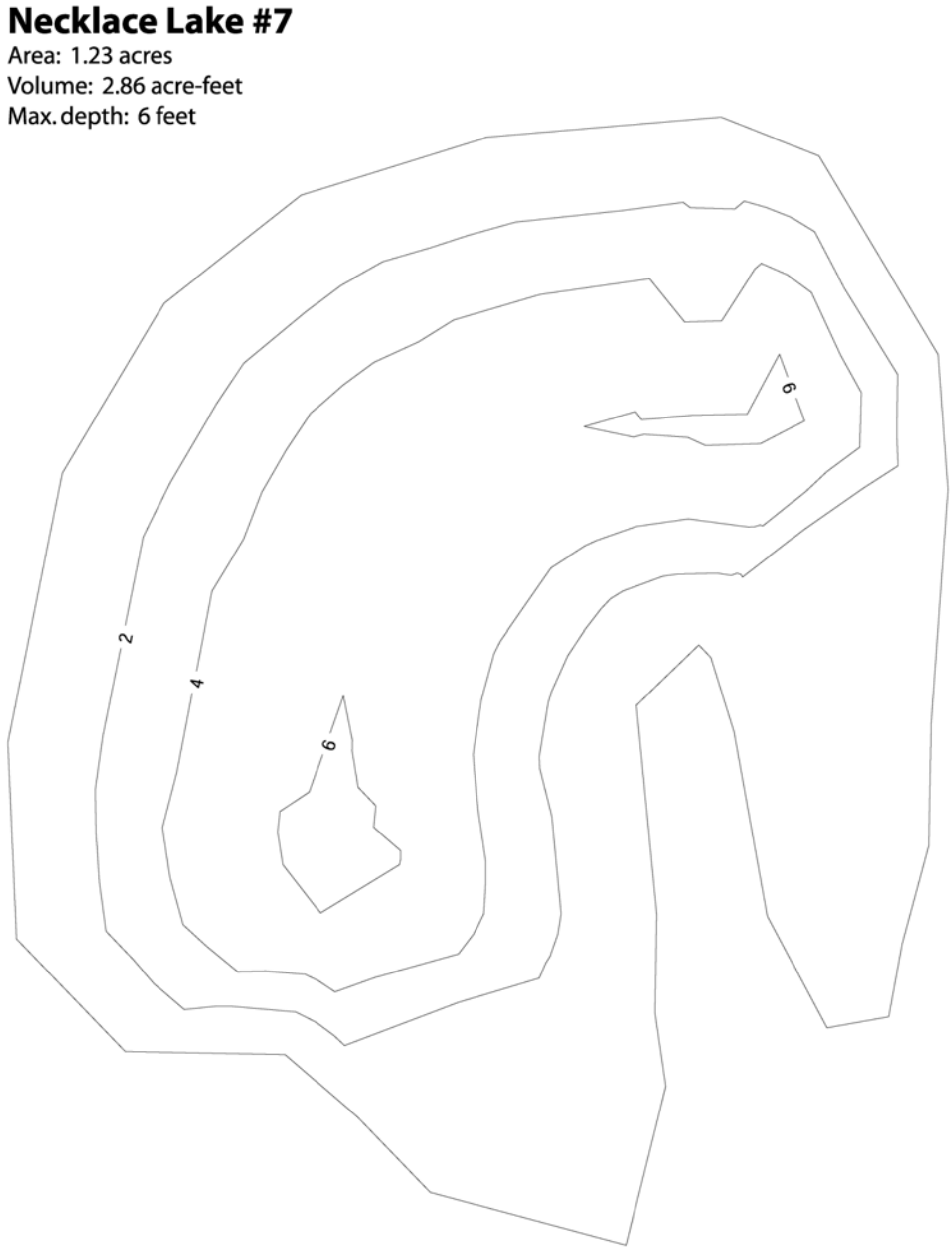

Figure B20. Bathymetric map of Necklace Lake #7.

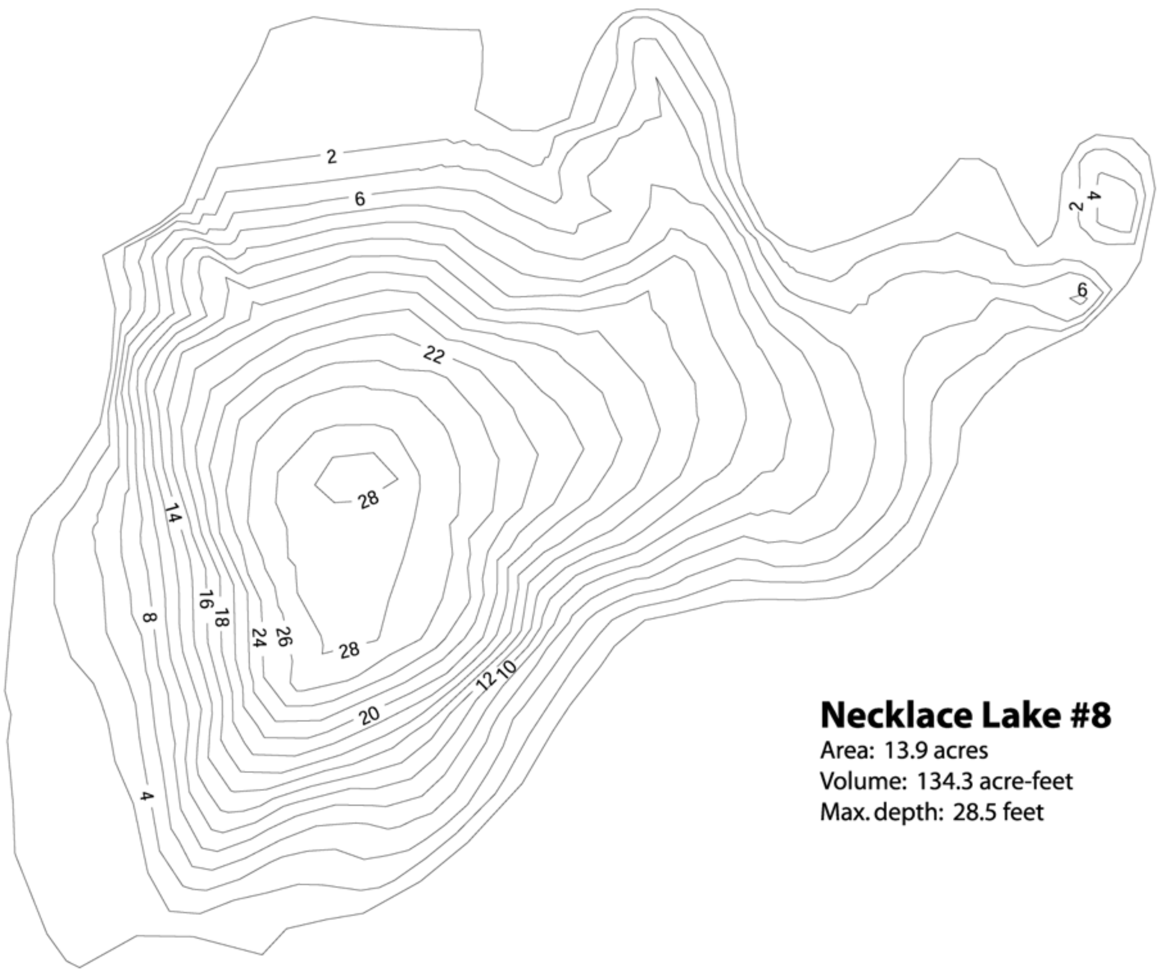

Figure 21. Bathymetric map of Necklace Lake #8

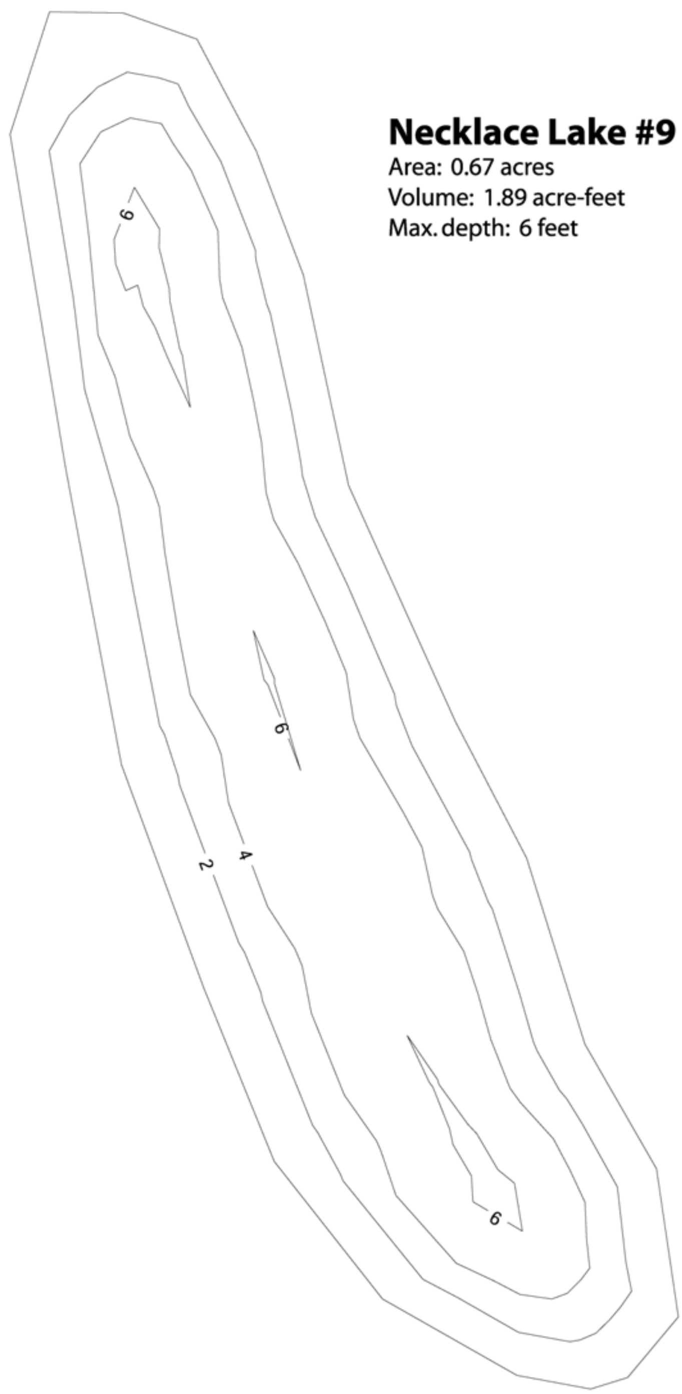

Figure B22. Bathymetric map of Necklace Lake #9.

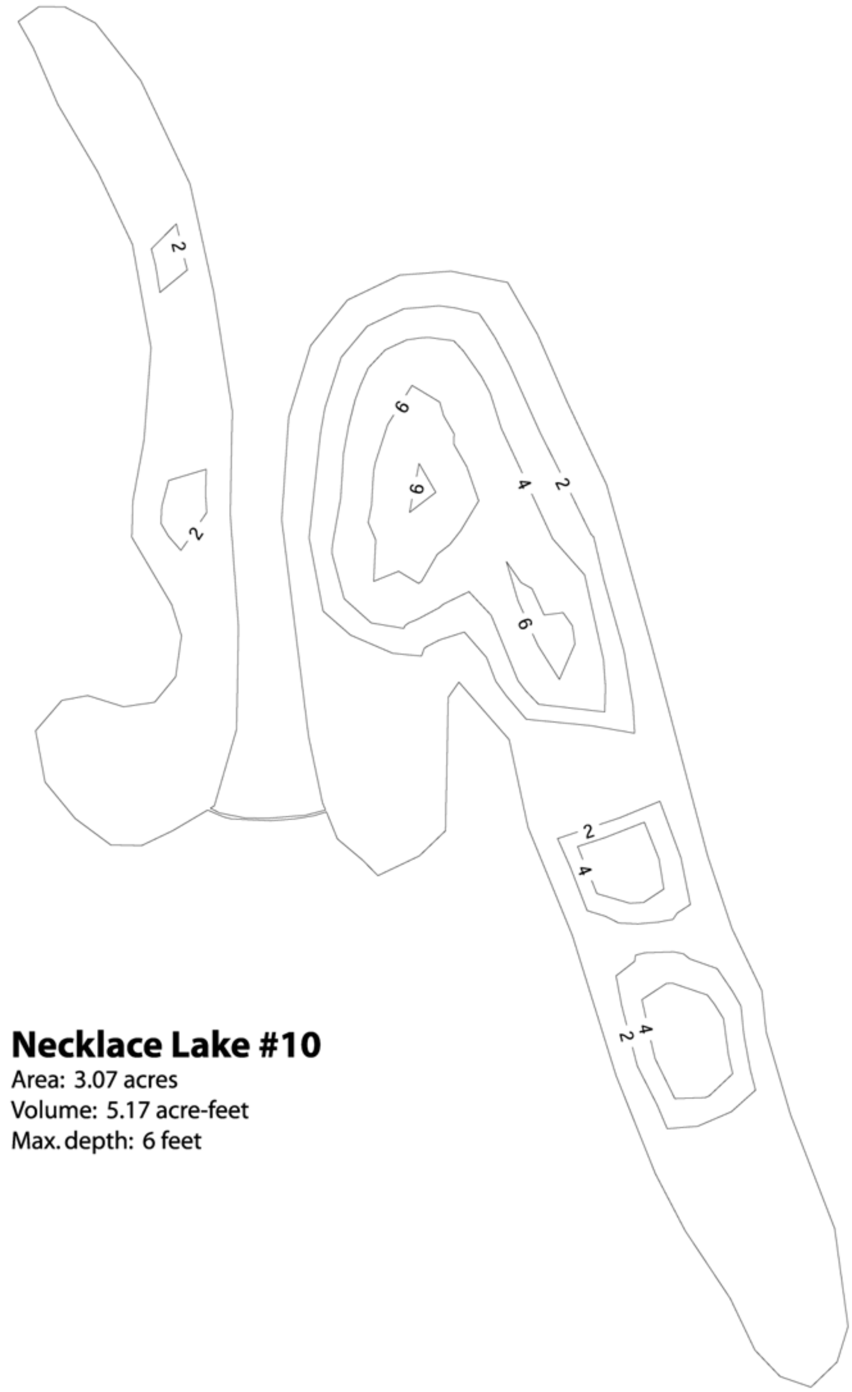

Figure B23. Bathymetric map of Necklace Lake #10.

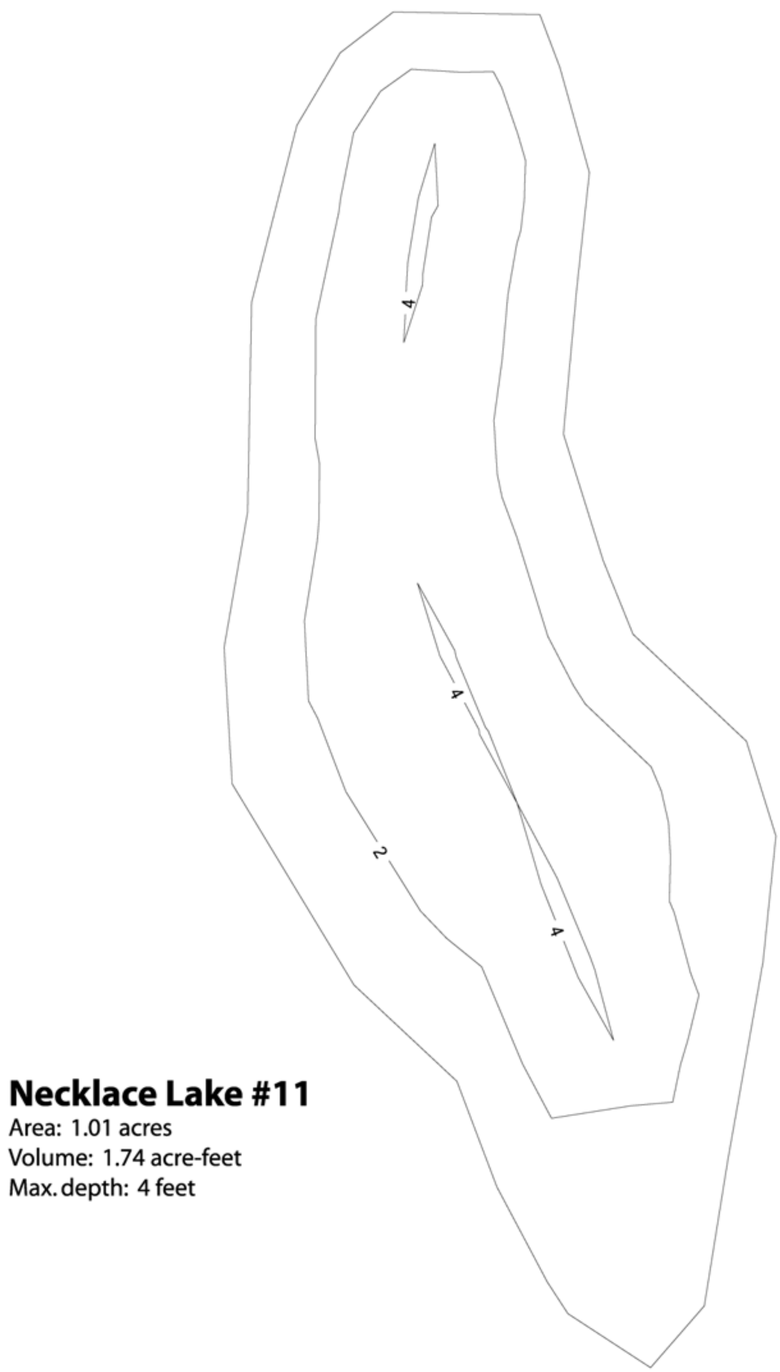

Figure B24. Bathymetric map of Necklace Lake #11.

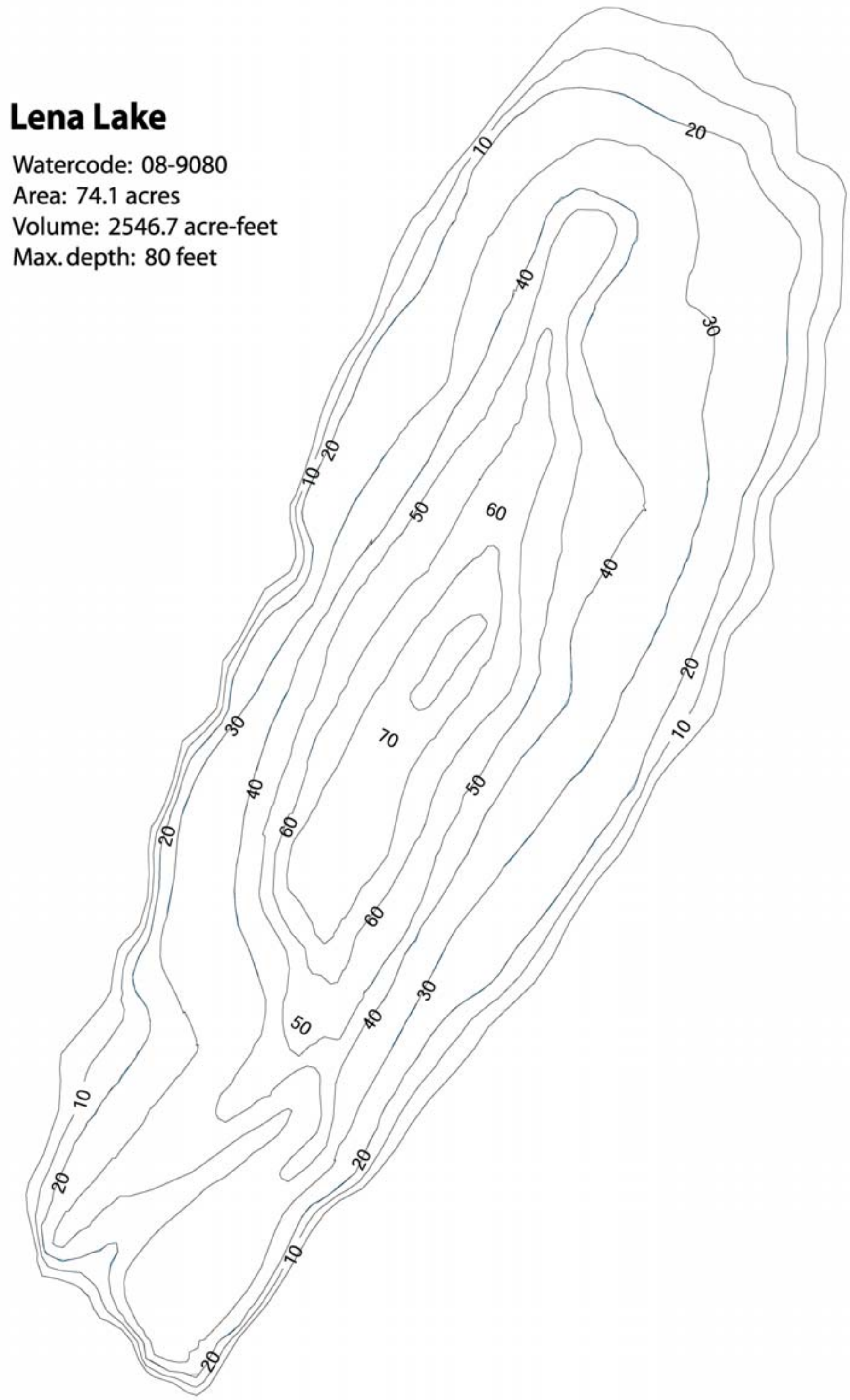

Figure B25. Bathymetric map of Lena Lake.

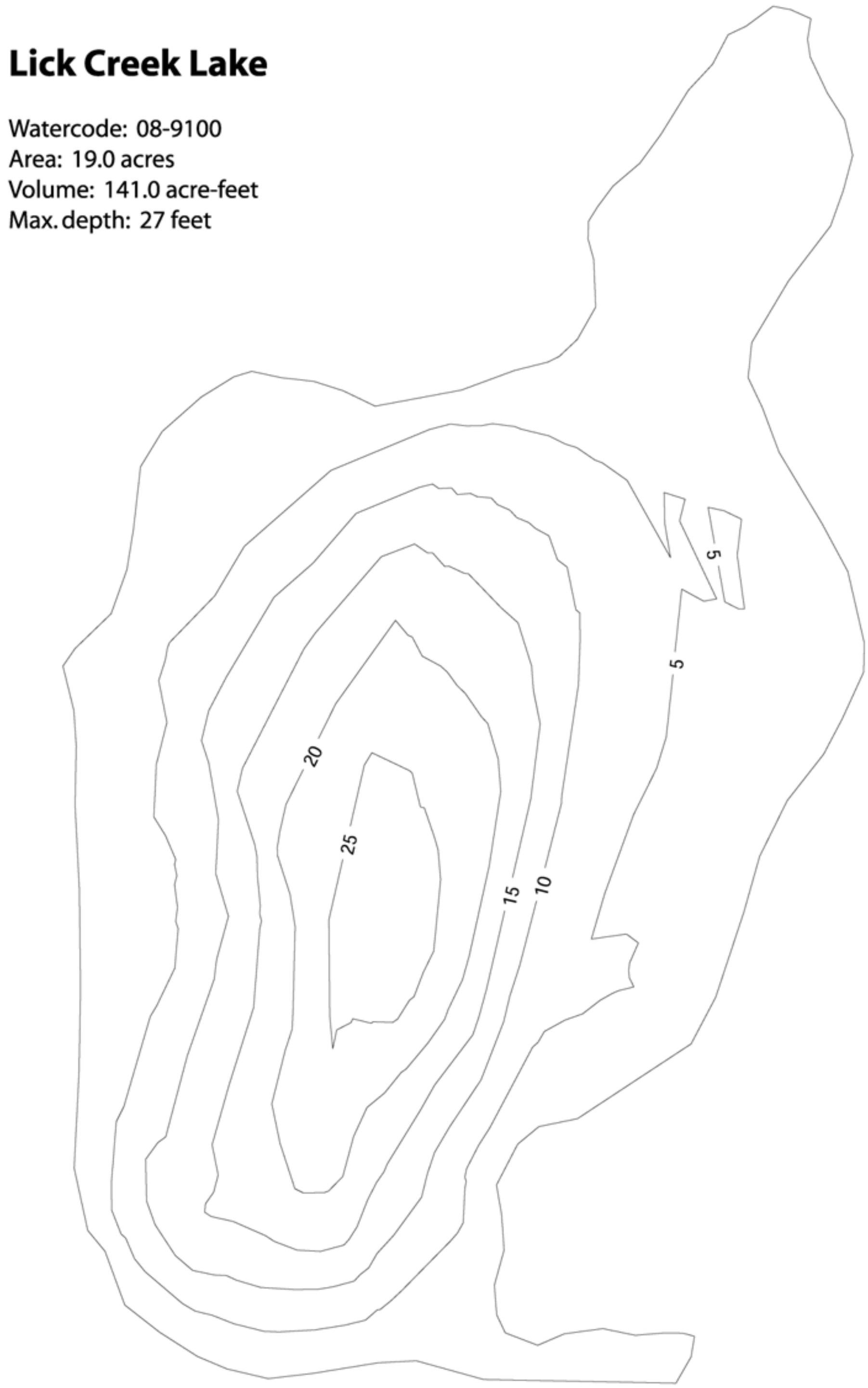

Figure B26. Bathymetric map of Lick Lake.

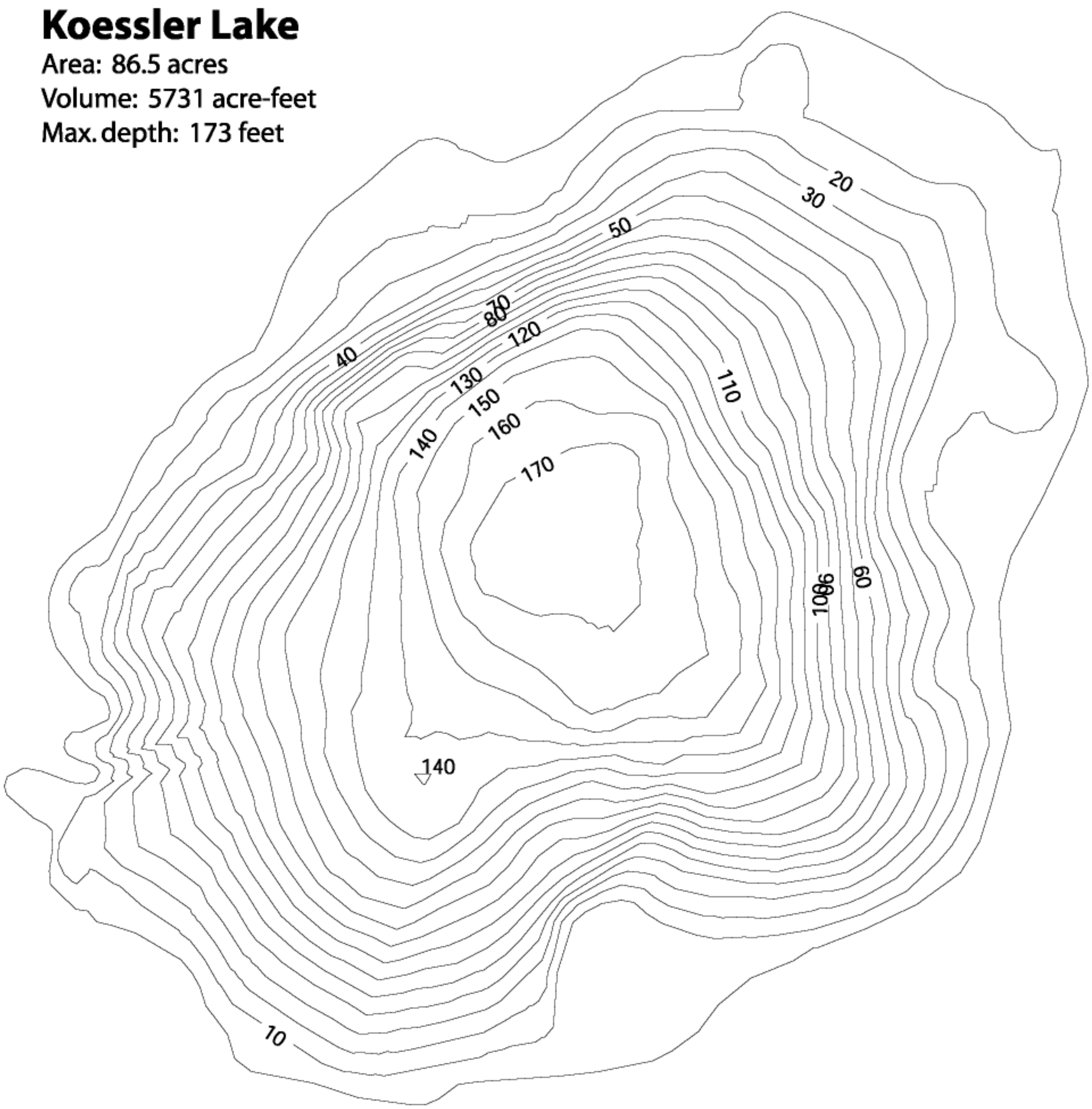

Figure B27. Bathymetric map of Koessler Lake.

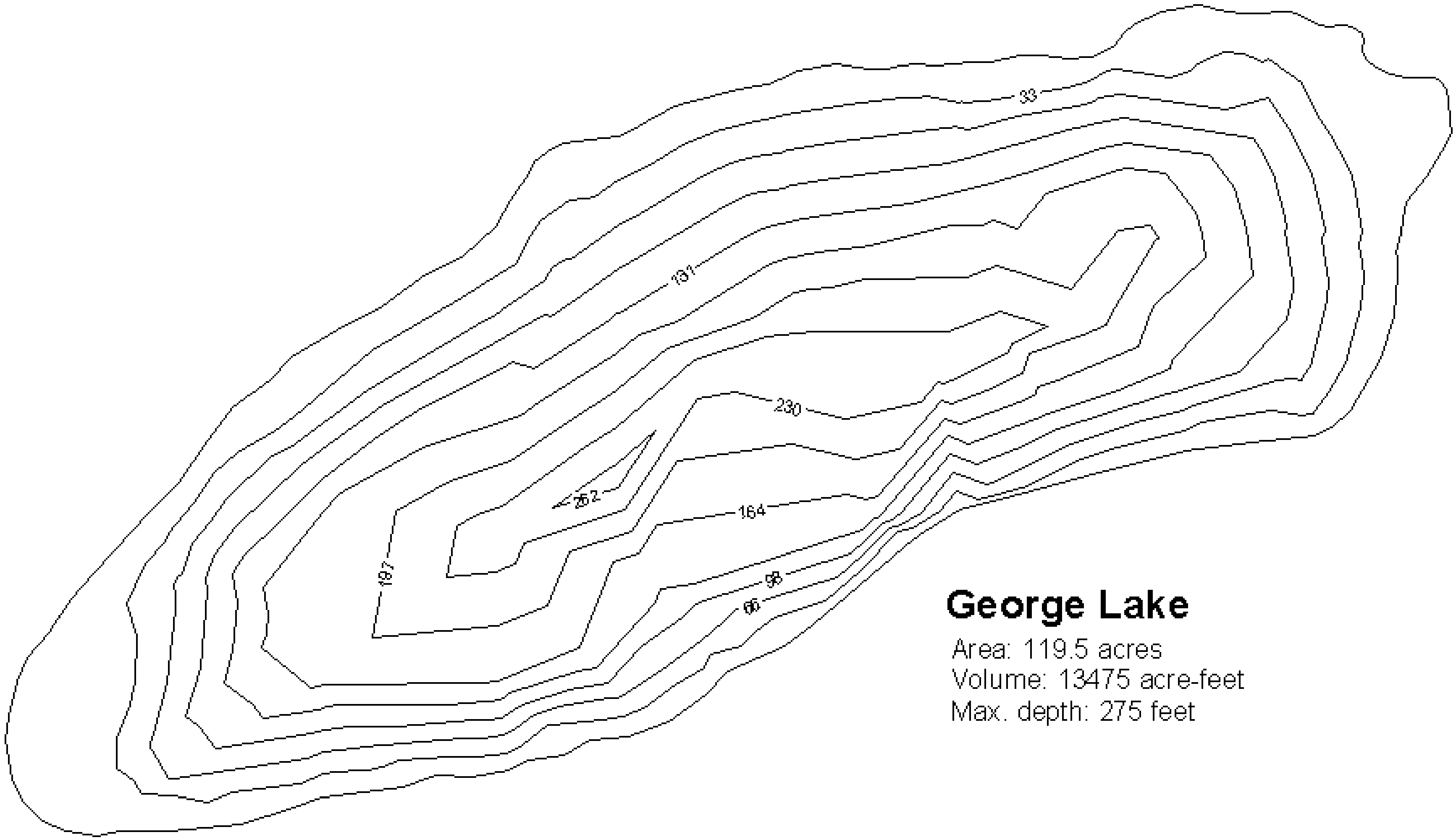

Figure B28. Bathymetric map of George Lake.

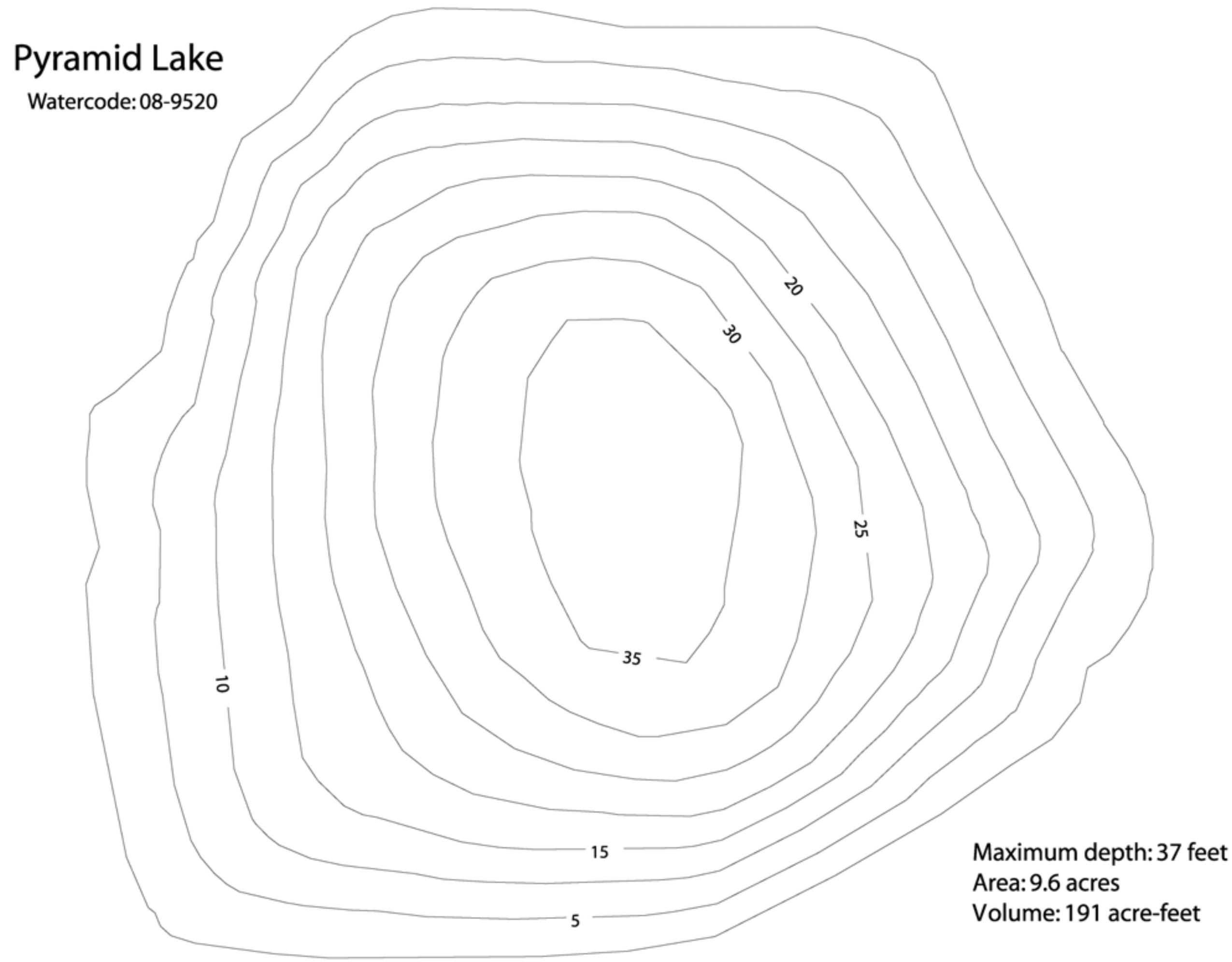

Figure B29. Bathymetric map of Pyramid Lake.

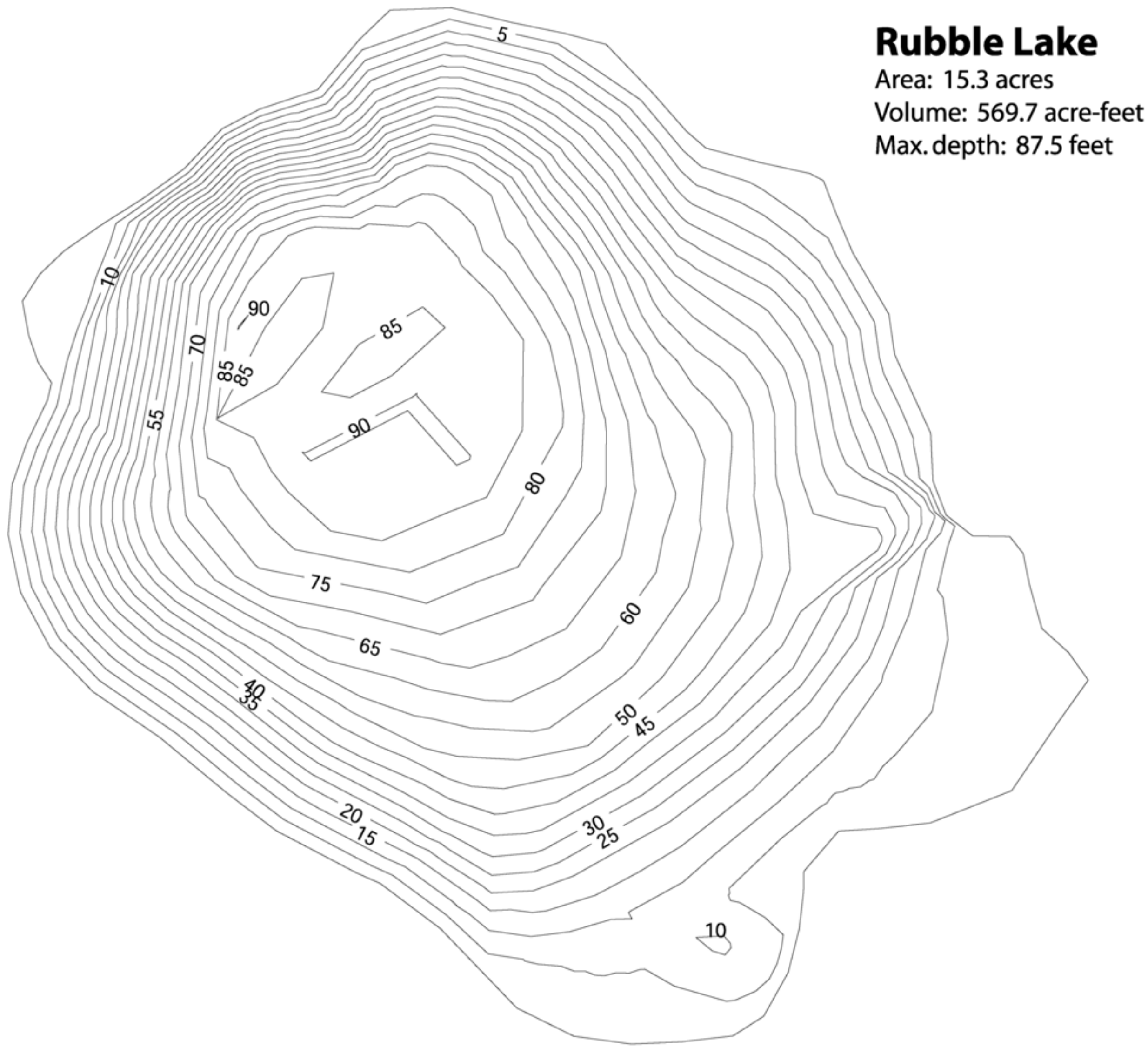

Figure B30. Bathymetric map of Rubble Lake.

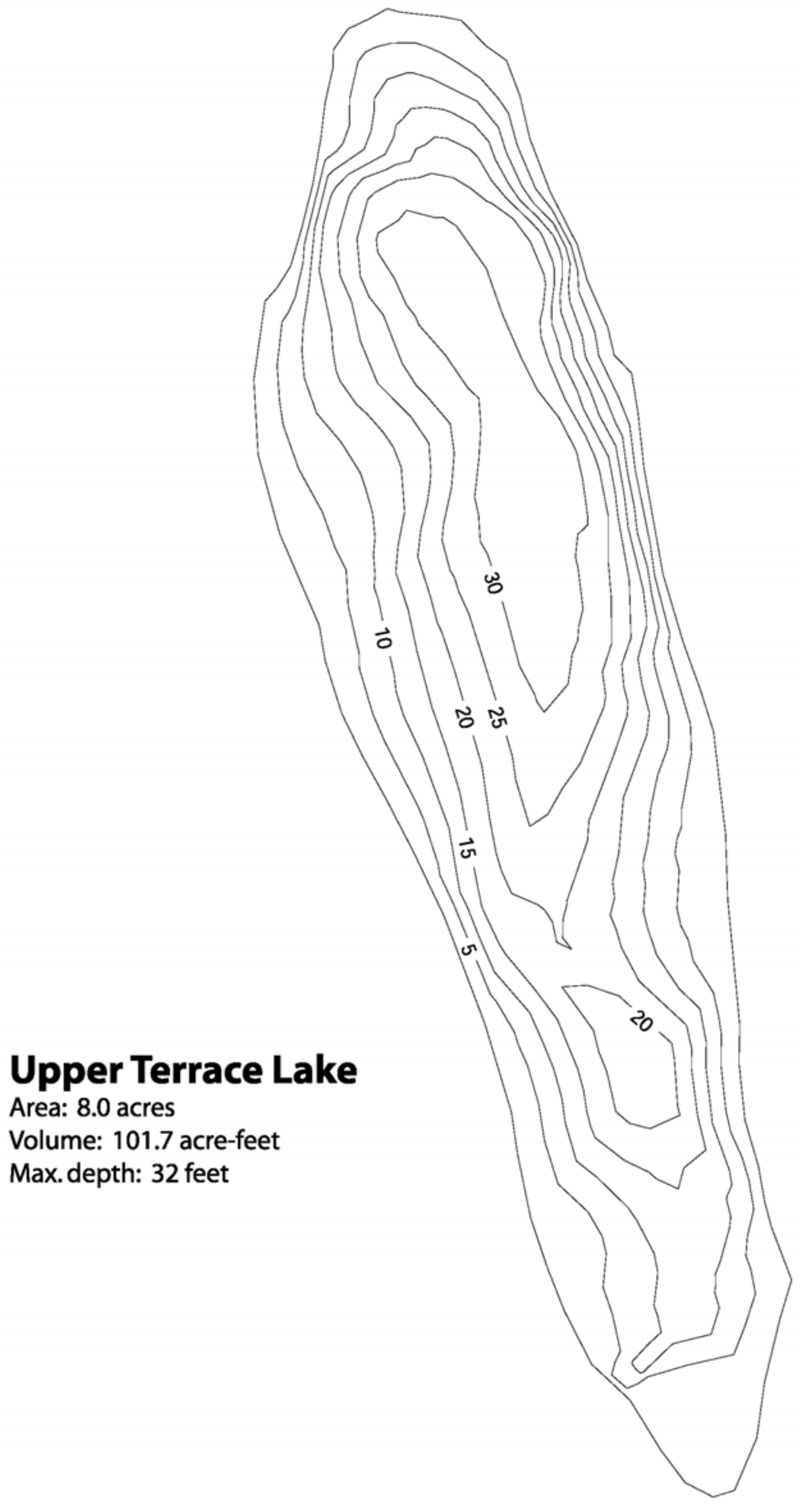

Figure B31. Bathymetric map of Upper Terrace Lake.

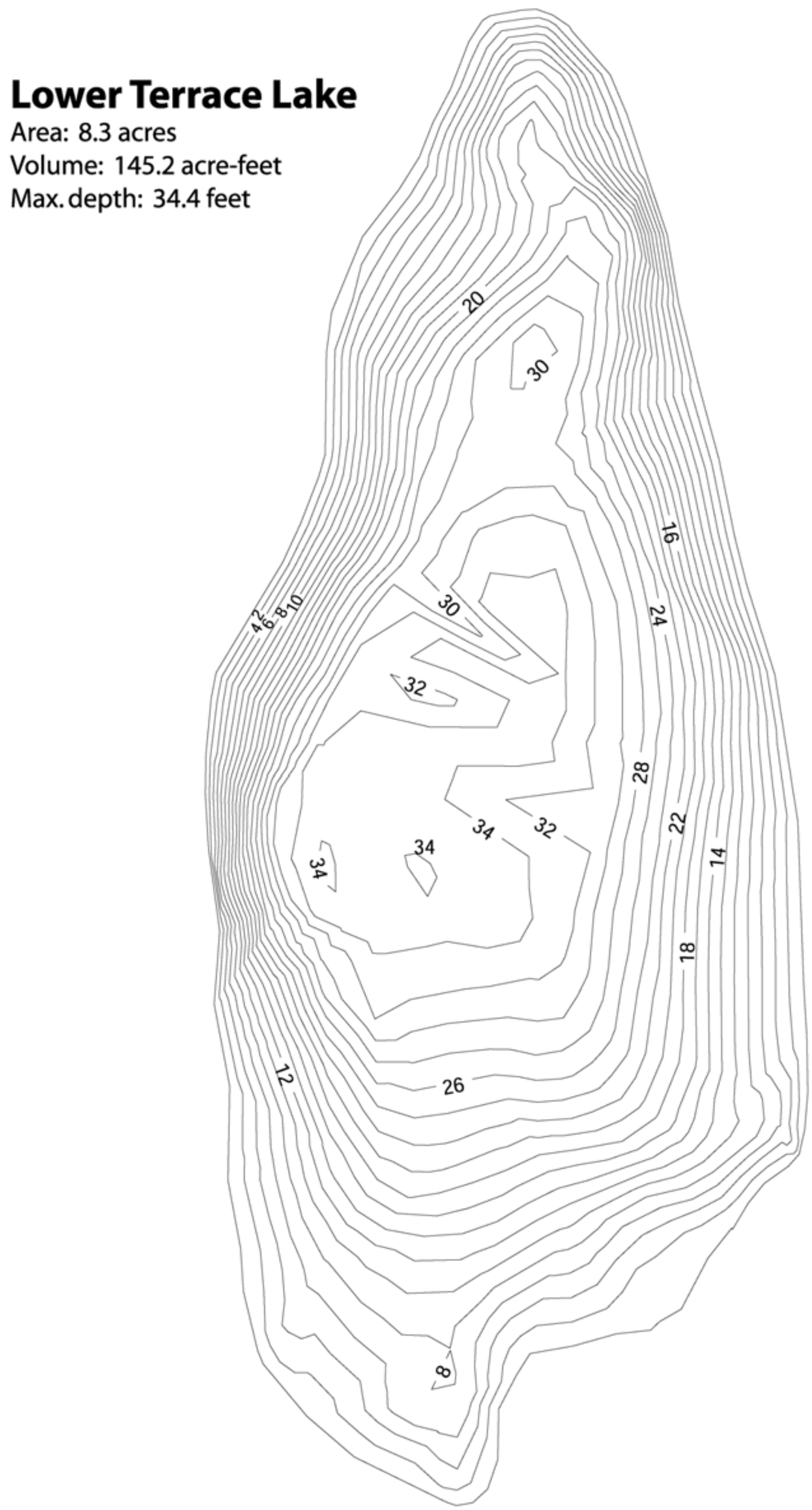

Figure B32. Bathymetric map of Lower Terrace Lake.

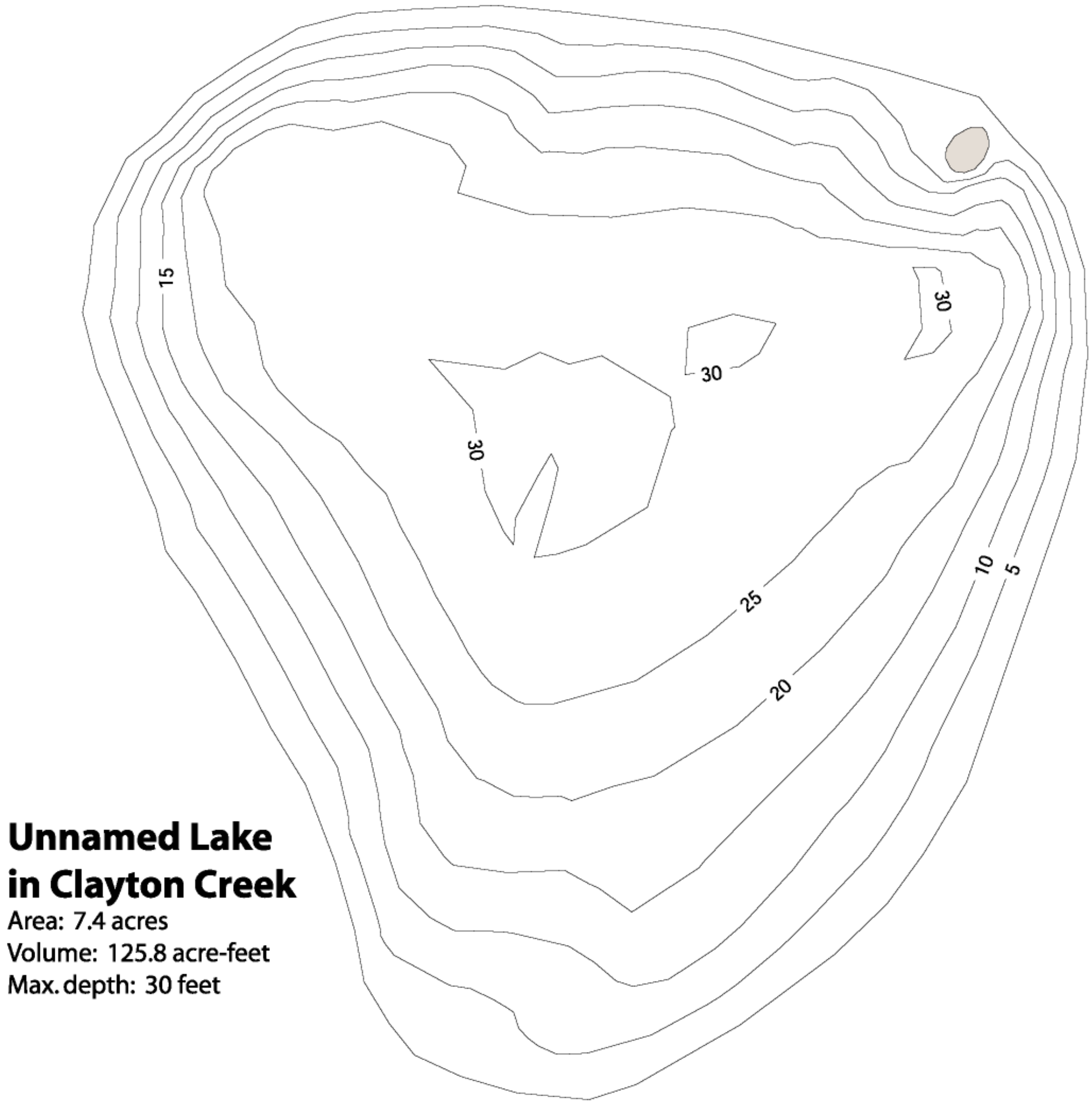

Figure B33. Bathymetric map of unnamed lake in Clayton Creek drainage.